NOTICE

All drawings located at the end of the document.

21000-WP-OU 02.07

EG&G

ROCKY FLATS

PILOT TEST PLAN
SOIL VAPOR EXTRACTION TECHNOLOGY

SUBSURFACE INTERIM MEASURES/ INTERIM REMEDIAL ACTION

EAST TRENCHES AREA

OPERABLE UNIT NO.2

Rocky Flats Environmental Restoration Project

JANUARY 1993

PILOT TEST PLAN

SOIL VAPOR EXTRACTION TECHNOLOGY

SUBSURFACE INTERIM MEASURES/INTERIM REMEDIAL ACTION

OPERABLE UNIT NO. 2

Revision #0

U.S. Department of Energy
Rocky Flats Plant
Golden, Colorado

12 JANUARY 1993

FINAL

Document No. 21000-WP-OU02.07

Prepared by:

EG&G Rocky Flats, Inc.
Rocky Flats Plant
Golden, Colorado 80401

2-11-93 EPA Approval

STATE OF COLORADO

COLORADO DEPARTMENT OF HEALTH
Dedicated to protecting and improving the health and environment of the people of Colorado

4300 Cherry Creek Dr. S.
Denver, Colorado 80222-1530
Phone (303) 692-2000

Laboratory Building
4210 E. 11th Avenue
Denver, Colorado 80220-3716
(303) 691-4700

Roy Romer
Governor

Patricia A. Nolan, MD, MPH
Executive Director

March 25, 1993

Mr. Richard J. Schassburger
U. S. Department of Energy
Rocky Flats Office, Bldg 116
P.O. Box 928
Golden, Colorado 80402-0928

RE: OU 2 Subsurface IM/IRA, Final Soil Vapor Survey Workplan and Final Soil Vapor Extraction Pilot Test Plan, January 12, 1993

Dear Mr. Schassburger,

The Colorado Department of Health, Hazardous Materials and Waste Management Division (the Division), has reviewed the above referenced documents submitted by DOE and prime operating contractor, EG&G. The Division hereby approves these plans.

If you have any questions regarding these matters, please call Joe Schieffelin of my staff at 692-3356.

Sincerely,

Gary W. Baughman

Gary W. Baughman, Chief
Facilities Section
Hazardous Waste Control Program

cc: Martin Hestmark, EPA
Scott Grace, DOE
Annette Primrose, EG&G
Jackie Berardini, CDH-OE

EG&G ROCKY FLATS PLANT	Manual:	21000-WP-OU02.07
	Revision No.:	0
	Page:	Table of Contents insert
	Effective Date:	
	Organization:	ER Env. Sci. & Engineering

APPROVED BY:

[signature] 9/7/93

Associate General Manager
Environmental Restoration

Date

APPROVED BY:

[signature] 09-02-93

Group/Project Manager
Environmental Restoration

Date

CONCURRENCE BY:

[signature] 9-7-93

ER Quality Assurance Program Manager

Date

TABLE OF CONTENTS
FINAL PILOT TEST PLAN SOIL VAPOR EXTRACTION TECHNOLOGY SUBSURFACE IM/IRA EAST TRENCHES AREA OPERABLE UNIT 2

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF DESIGN DRAWINGS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF ACRONYMS

abs	absolute
acfm	actual cubic feet per minute
Am	Americium
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
bgs	below ground surface
BHP	brake horsepower
CCl_4	carbon tetrachloride
CDH	Colorado Department of Health
CFR	Code of Federal Regulations
CMS/FS	corrective measures study/feasibility study
CPVC	chlorinated polyvinyl chloride
DNAPL	dense, nonaqueous-phase liquid
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
dpm	disintegrations per minute
DQO	data quality objectives
EPA	U.S. Environmental Protection Agency
FID	flame ionization detector
GAC	granular activated carbon
GC	gas chromatograph
gpm	gallons per minute
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
HDPE	high-density polyethylene
HEPA	high efficiency particulate air
Hg	mercury
HNu	HNu photoionization detector
Hz	hertz
IHSS	individual hazardous substance site
IM/IRA	interim measures/interim remedial action
lbs	pounds
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MSL	mean sea level
NEC	National Electrical Code
ORR	Operational Readiness Review
OSHA	Occupational Safety and Health Administration
OU2	Operable Unit No. 2
OVA	organic vapor analyzer
PARCC	precision, accuracy, representiveness, completeness, and comparability
pCi/g	picocuries per gram

GLOSSARY OF ACRONYMS

PID	photoionization detector
P&ID	process and instrumentation diagram
PM	pressure monitoring
ppm	parts per million
ppmv	parts per million volume/volume
psi	pounds per square inch
Pu	plutonium
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RFP	Rocky Flats Plant
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RPM	revolutions per minute
scfm/ft	standard cubic feet per minute per foot
SO	system operations
SOP	standard operating procedures
SVE	soil vapor extraction
T-4	Trench T-4 (IHSS No. 111.1)
TCA	1,1,1-trichloroethane
TCE	trichloroethene
U	uranium
V	volts
VOC	volatile organic compound

Project Manager

Quality Assurance Program Manager

SECTION 1
INTRODUCTION

The U.S. Department of Energy (DOE) has previously prepared an Interim Measures/Interim Remedial Action (IM/IRA) Plan to investigate the removal of volatile organic compound (VOC) contamination suspected in the subsurface within an area of the Rocky Flats Plant (RFP) identified as Operable Unit No. 2 (OU2) (EG&G, 1992). The IM/IRA Plan identified soil vapor extraction[1] (SVE) as a potentially applicable technology to be implemented as a Subsurface IM/IRA at OU2. Further, the IM/IRA Plan identified three locations at which SVE will be pilot tested. This Test Plan provides guidance for implementation of the pilot-scale SVE at the East Trenches Area of OU2.

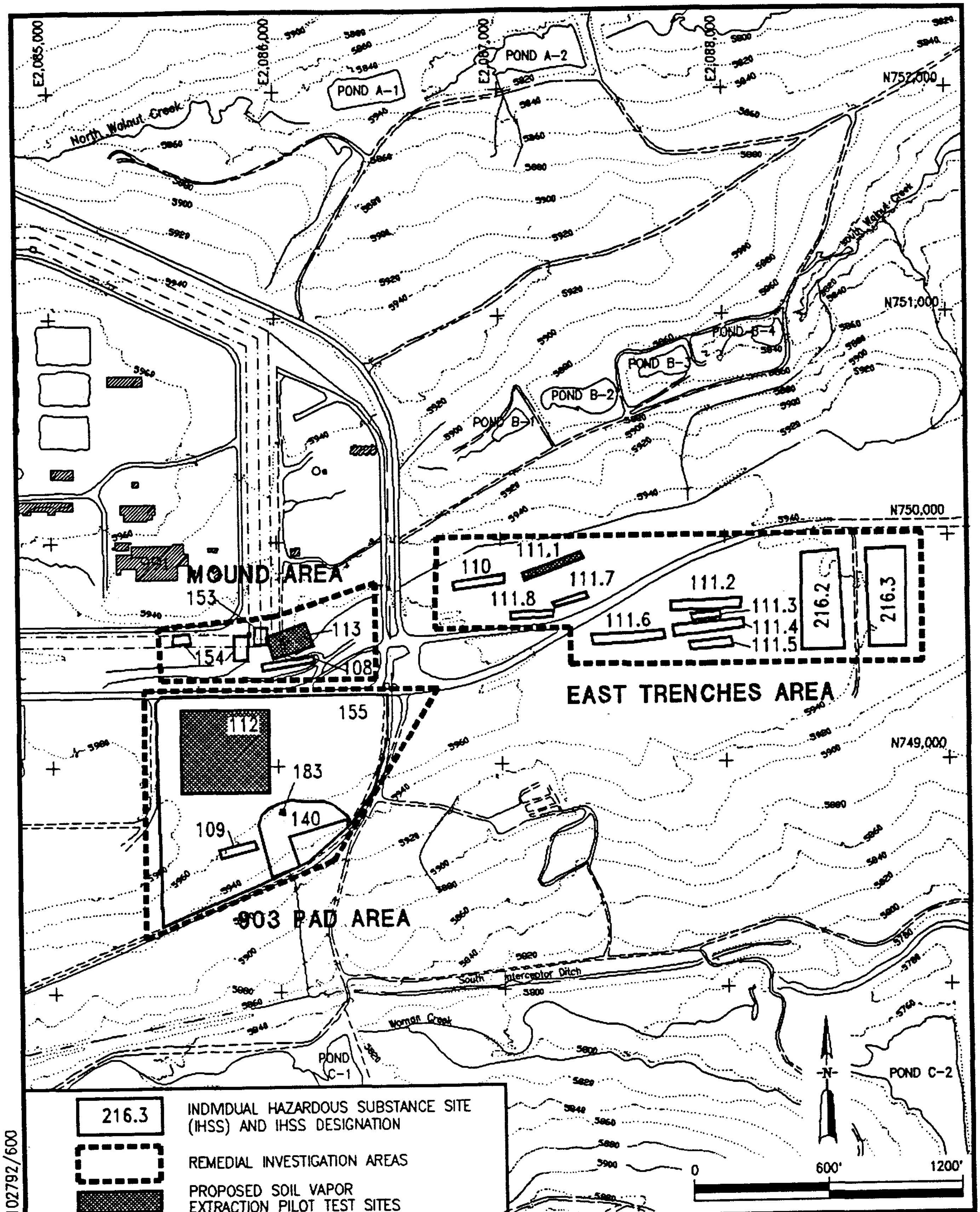
This Pilot Test Plan addresses SVE at a test site adjacent to Individual Hazardous Substance Site (IHSS) No. 111.1 (Figure 1-1). IHSS No. 111.1 is also known as Trench T-4, and will be referred to as T-4 throughout this document. This Test Plan provides a performance specification for design and construction of the SVE pilot system. The Plan also includes procedures for system operations testing, performance monitoring, and field testing of the pilot system at T-4. The pilot test procedures presented in this plan have been developed in accordance with the U.S. Environmental Protection Agency's (EPA) guidance for conducting soil vapor extraction treatability studies (EPA, 1991a).

[1] Soil vapor extraction is also known as vacuum-enhanced vapor extraction, *in situ* volatilization, soil venting, and in situ soil stripping.

Project Manager

Quality Assurance Program Manager

1) **FIGURE 1-1 Proposed Test Site Locations - OU2**



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

PROPOSED SOIL VAPOR EXTRACTION PILOT TEST SITES OPERABLE UNIT NO. 2

FIGURE 1-1

1.1 PROJECT BACKGROUND

A brief summary of the remedial investigation/feasibility study (RI/FS) activities conducted to date at OU2 is presented below. A more complete discussion of these activities may be found in the Subsurface IM/IRA Plan (EG&G, 1992b).

A Phase I RI was conducted at OU2 in 1987, and consisted of the preparation of detailed topographic maps, radiometric and organic vapor screening surveys, surface geophysical surveys, a soil gas survey, a boring and well completion program, soil sampling, and surface and ground-water sampling. Phase I data did not completely define the nature and extent of contamination for the purpose of conducting a baseline risk assessment and an FS of remedial alternatives pertaining to contaminated media (Rockwell International, 1987).

Therefore, a Phase II RI (alluvial system) began in October 1991 to further characterize OU2. The Phase II RI includes the advancement of soil borings into waste sources to characterize any waste materials remaining in place, installation of ground-water monitor wells adjacent to some of the boreholes to characterize ground-water quality directly beneath the suspected waste source sites, and installation of additional alluvial monitoring wells to further characterize and monitor ground-water flow and quality in alluvial materials at OU2.

In recent years, DOE has prepared several IM/IRA Plans to address ground water, surface water, and subsurface soil contamination at OU2. A draft of the first such plan was prepared by DOE in 1989 to address contaminated OU2 groundwater (Rockwell International, 1989). The plan was prepared based on limited knowledge of the nature and extent of ground-water contamination at OU2. Regulatory agency review of the document determined that, although an IM/IRA for ground water is required by the Inter-Agency Agreement (EG&G, 1991d), insufficient information existed on the nature and extent of ground-water contamination to pursue effective ground-water remediation at that time. Therefore, pursuit of an IM/IRA for remediation of OU2 ground water was deferred until Phase II RI data were collected.

In March 1991, DOE submitted an IM/IRA Plan addressing contaminated surface water within the South Walnut Creek drainage basin (EG&G, 1991a). The Plan proposed that contaminated surface water be collected and treated by chemical precipitation and microfiltration for removal of radionuclides and metals, followed by treatment by granular activated carbon (GAC) adsorption for removal of VOCs. Installation of the Surface Water IM/IRA was completed on 24 April 1992, and system startup occurred on 27 April 1992. Pilot testing of the South Walnut Creek IM/IRA treatment system is scheduled to continue through the Summer of 1993.

DOE submitted a second Surface Water IM/IRA Plan for OU2 in October 1991 (EG&G, 1991b). This Plan considered several alternatives for the collection and treatment of contaminated surface seepage within the Woman Creek Basin. The Plan also presented a detailed evaluation of the impacts to human health and the environment associated with the contaminated seepage, the results of which indicated that no immediate threat to public health or the environment existed. Thus, the IM/IRA Plan presented the No Action Alternative as the preferred alternative. Meetings between DOE, EPA, and the Colorado Department of Health (CDH) were held subsequent to submission of the IM/IRA Plan to discuss alternative IM/IRAs that could be conducted at OU2 in lieu of the originally conceived Woman Creek Basin surface water action. The result of these discussions was an agreement that a better use of resources was to pursue an IM/IRA that addressed suspected residual, free-phase VOC contamination in the subsurface at one or more OU2 areas. It was further agreed that since subsurface VOC contamination at OU2 does not pose an immediate threat to public health and the environment, the IM/IRA should primarily be used to gain information that will aid in selection and design of final remedial actions at OU2.

In September 1992, DOE released a final Subsurface IM/IRA Plan to investigate on a pilot scale, the removal of VOC contamination from three areas within OU2. Specifically, the Plan involves pilot testing the SVE technology within or adjacent to suspected VOC source areas in the 903 Pad, Mound, and East Trenches Areas. The locations of the proposed pilot test sites are illustrated in Figure 1-1. An overview of the pilot study investigations that will be conducted at each of the proposed test sites is presented below.

903 PAD (IHSS NO. 112):

- SVE coupled with ground-water depression in the alluvium.
- SVE in the upper portion of the claystone bedrock.

MOUND SITE (IHSS NO. 113):

- SVE in the alluvium.
- SVE in the upper portion of the underlying claystone bedrock.

EAST TRENCHES AREA (IHSS NO. 111.1):

- SVE in the alluvium.
- SVE coupled with ground-water depression in the sandstone bedrock.

In addition to the investigations listed above, the Subsurface IM/IRA also includes examination of passive and active air injection at those sites where enhancement to the VOC mass recovery rate would be expected.

It should be noted that in addition to IHSS Nos. 112, 113, and 111.1, there are other candidate soil vapor extraction test sites located within OU2. Examples include IHSS Nos. 109 and 110. IHSS No. 109 is a burial trench located approximately 300 feet south of the 903 Pad. IHSS No. 110 is a burial trench in the East Trenches Area. One or more alternative locations may be substituted for IHSS Nos. 112, 113, and 111.1 if OU2 Phase II RI and soil vapor survey data (EG&G, 1992a) suggest that the alternative sites would better serve the Pilot Test Program.

1.2 OBSERVATIONAL/STREAMLINED APPROACH

Due to the uncertainties associated with the expected hydrogeology and nature and extent of contamination within the OU2 subsurface, DOE has incorporated EPA Observational/Streamlined Approach guidance in the planning of the Subsurface IM/IRA. The Observational/Streamlined Approach provides a means of building the required degree of flexibility into the planning and implementation of an environmental restoration project to overcome potential deviations in expected site conditions, and to better ensure project success. These goals are achieved by planning for reasonably conceivable deviations in expected site conditions and using new site data as they become available throughout the course of the project to modify the IM/IRA as appropriate. The use of this approach should also streamline the IM/IRA, and ultimately reduce the cost and time required for implementation.

The SVE system performance specifications and pilot test procedures presented in this Test Plan have been developed to offer as much flexibility in design and implementation of the IM/IRA as possible. Specifications for the vacuum extraction unit, for example, have been prepared to accommodate a wide range in soil permeability from test site to test site. Similarly, rather than specifying the exact depths and screened intervals for the extraction and injection vents, the Test Plan provides guidance for field sizing based on the actual geology of the soil boring. It should be noted, however, that it is not possible to offer complete design and implementation flexibility due to time constraints and resource limitations. Major modifications to the original design can have significant adverse impacts to the project schedule and budget.

Additional information on the EPA Observational/Streamlined Approach and its application to the Subsurface IM/IRA is presented in EPA Office of Solid Waste and Emergency Response Directive No. 9355.3-06 (EPA, 1989b) and the Subsurface IM/IRA Plan (EG&G, 1992b).

1.3 PILOT STUDY OBJECTIVES

The SVE pilot study described herein has several objectives. Foremost, the pilot study will be used to assess the potential for SVE to remove VOC contamination suspected in the subsurface in the East Trenches Area. If SVE is determined to be a viable remedial technology, the pilot study will provide information to support evaluation of SVE as a remedial action alternative for subsurface contamination at the East Trenches. This information will be incorporated into the Corrective Measures Study/Feasibility Study (CMS/FS) for OU2. In addition to gathering technical information about the SVE technology, it is also an objective to minimize potential adverse environmental impacts during the study. To this effect, numerous control features have been included in the system design (see Section 6).

1.4 MODIFICATIONS TO THE SUBSURFACE IM/IRA PLAN

The pilot test program presented in this document for examining the performance of SVE technology at the East Trenches Area reflects several modifications to the conceptual program presented in the Subsurface IM/IRA Plan (EG&G, 1992). Per Observational/Streamlined Approach methodology, these modifications were made based on new information regarding the proposed test site that became available since publication of the final Subsurface IM/IRA Plan. Enhancements were also made to the proposed system design as work progressed. The significant modifications are noted below, along with the rationale behind the changes. It is important to note that additional modifications to those listed below may be incorporated into future drafts of the Test Plan as new data become available. This Subsection of the Test Plan is reserved to inform the reader of all significant changes.

This Test Plan specifies that the vapor treatment process (i.e., HEPA filters, GAC units, etc.) is to operate at less than atmospheric pressure as opposed to the positive pressure scenario presented in the IM/IRA Plan. Negative pressures are achieved by placing the extraction blower(s) towards the end of the treatment train. Such a configuration has the advantage of preventing contaminated vapor leaks prior to HEPA filtration and GAC adsorption treatment. Instead, if a breach (i.e., crack) in the process piping occurs, the negative pressure will cause atmospheric air to be "pulled" into the treatment train. The Test Plan also specifies a dual blower configuration (rather than a single blower) for increased operating efficiency.

The Pilot Test Plan presents an expected ground-water recovery rate at the East Trenches Area test site (i.e., IHSS No. 111.1) of 5 gpm in contrast to a 1 gpm extraction rate discussed in the Subsurface IM/IRA Plan. This upward revision is based on pump test data for the East Trenches Area that became available after the IM/IRA Plan was finalized.

The Pilot Test Plan specifies that the process gas stream is to be sampled at the exhaust stack to verify the absence of radioactive species as opposed to just downstream of the inline HEPA filters. This modification has two primary advantages. First, the vapors at the exhaust stack (i.e., downstream of the GAC adsorption units) will be free of VOCs. This configuration thus represents an advantage from a health and safety standpoint. Operators will not be exposed to fugitive VOCs when removing sample filters for subsequent measurement of radioactivity. Second, sampling at the exhaust stack requires a lower duty pump since the stream is at essentially atmospheric pressure rather than at negative pressure.

The SVE Test Plan includes pilot tests involving passive and active air injection. The active air injection specified in the Test Plan involves air that is heated by virtue of the energy imparted by the injection blower. In contrast, the Subsurface IM/IRA Plan proposes the testing of active air injection only, and that separate tests would be conducted to examine injection of air at ambient temperature and air heated by an indirect-fired heater. Modification of the strategy proposed in the Subsurface IM/IRA Plan was based on the following rationale. The heat imparted to the air stream by the blower eliminates the necessity for a heater. In addition, cooling the air stream leaving the blower to achieve an ambient temperature defeats the goal of enhancing volatilization.

1.5 TEST PLAN ORGANIZATION

This Subsection outlines the organization of the Test Plan. Section 2 of this report provides a characterization of the East Trenches Area, which includes descriptions of site background, geology, and hydrogeology. Subsection 2.1 has largely been derived from the IM/IRA Plan. In addition, an overview of the SVE technology and its applicability to suspected subsurface contamination at T-4 is presented in Section 2.

Section 3 describes the general design considerations which need to be addressed in implementing the SVE technology at a generic location. These design considerations are then applied to develop the design basis for the pilot SVE system at T-4. Should the pilot SVE system be implemented at a location other than T-4, the general design considerations presented in Section 3 will need to be reevaluated.

Section 4 outlines the construction specifications and performance requirements for the pilot SVE system vapor extraction vents, air injection vents, ground-water extraction wells, pressure monitoring probes, and vapor manifolds. Sampling and analysis activities to be implemented during system installation are described.

Section 5 summarizes the T-4 site preparations which will be performed prior to system installation, such as access road and ground-water storage tank constructions. Equipment connection procedures to be performed subsequent to system installation are also presented.

Section 6 describes the construction specifications and performance requirements for the mobile pilot-scale vapor extraction unit. The vapor extraction unit consists of the major system equipment, which include the positive displacement blowers, a demister, the high-efficiency particulate air (HEPA) filters, and the vapor treatment system. In addition, system monitoring and instrumentation requirements are outlined.

Section 7 summarizes the pilot system tests to be conducted. A series of nine pilot tests are presented, whose results will be used to determine the system's optimal operating configuration. Subsequent sustained operations to be performed are presented. A post-pilot operations sampling and analysis program is also described. Data collection procedures to be followed during the pilot operations are presented.

Section 8 outlines the data reporting and evaluation requirements for the pilot tests and the sustained operations. The various data tables and figures to be prepared are indicated. Procedures for determining the optimal system operating configuration and individual strata permeabilities to air flow are described.

Section 9 provides the schedule for conduct of the Subsurface IM/IRA pilot study at the East Trenches Area test site.

Appendix A presents several engineering drawings that detail the design of the pilot-scale vapor extraction unit. The drawings address extraction/injection well and vapor treatment system construction. Appendix B is reserved for future use. Appendix C presents the soil boring logs that were used to create the hydrogeological concept models for the pilot test sites. Appendix D presents the quality assurance procedures that will be followed during conduct of the soil vapor extraction pilot test program. Appendix E includes the engineering calculations that provide the basis for the design of the vapor extraction pilot unit. Appendix F provides a list of RFP Standard Operating Procedures (SOPs) that are applicable to the Subsurface IM/IRA Pilot Test Program. The SOPs include procedures for sampling, well construction, and decontamination.

SECTION 2

PILOT STUDY SCOPE

2.1 EAST TRENCHES AREA CHARACTERIZATION

2.1.1 Introduction

Expected conditions in the East Trenches Area described in this Section, with respect to hydrogeology and contaminant distribution, are based on Phase I and Phase II RI data coupled with historical contaminant release information. The development of an area-wide and site-specific hydrogeologic and contaminant distribution model is a continuing process in which new data from the Phase II Alluvial RI is incorporated as it becomes available.

This evolution is evident by the subtle differences in the test site conceptual model presented in the Subsurface IM/IRA Plan (EG&G, 1992b) as compared with that presented in this Section. The model presented in the IM/IRA Plan was based primarily on Phase I RI data which did not include any exploratory soil borings or sampling within the actual IHSSs. Therefore, the IM/IRA Plan presented expected site conditions extrapolated from data collected near the proposed test site. During the preparation of the Test Plan, it was possible to review field data collected as part of the Phase II RI which included investigative efforts within the actual IHSSs and the proposed test site (IHSS 111.1). This permitted refinement of the conceptual model which now reflects the actual hydrogeologic and contaminant distribution conditions at the proposed test site.

Based on Phase II RI chemical data, IHSS 110 (Trench T-3, Figure 1-1) is considered a possible alternate SVE test location. A soil sample collected from this IHSS contained over 10,000 mg/kg of perchloroethylene. It is important to note that evaluation of additional data will be conducted as they become available with respect to finalizing the test site location (within IHSS 111.1 or at an alternate site). This includes the results of a soil vapor survey (EG&G, 1992a) to be conducted at OU2 during the first half of 1993.

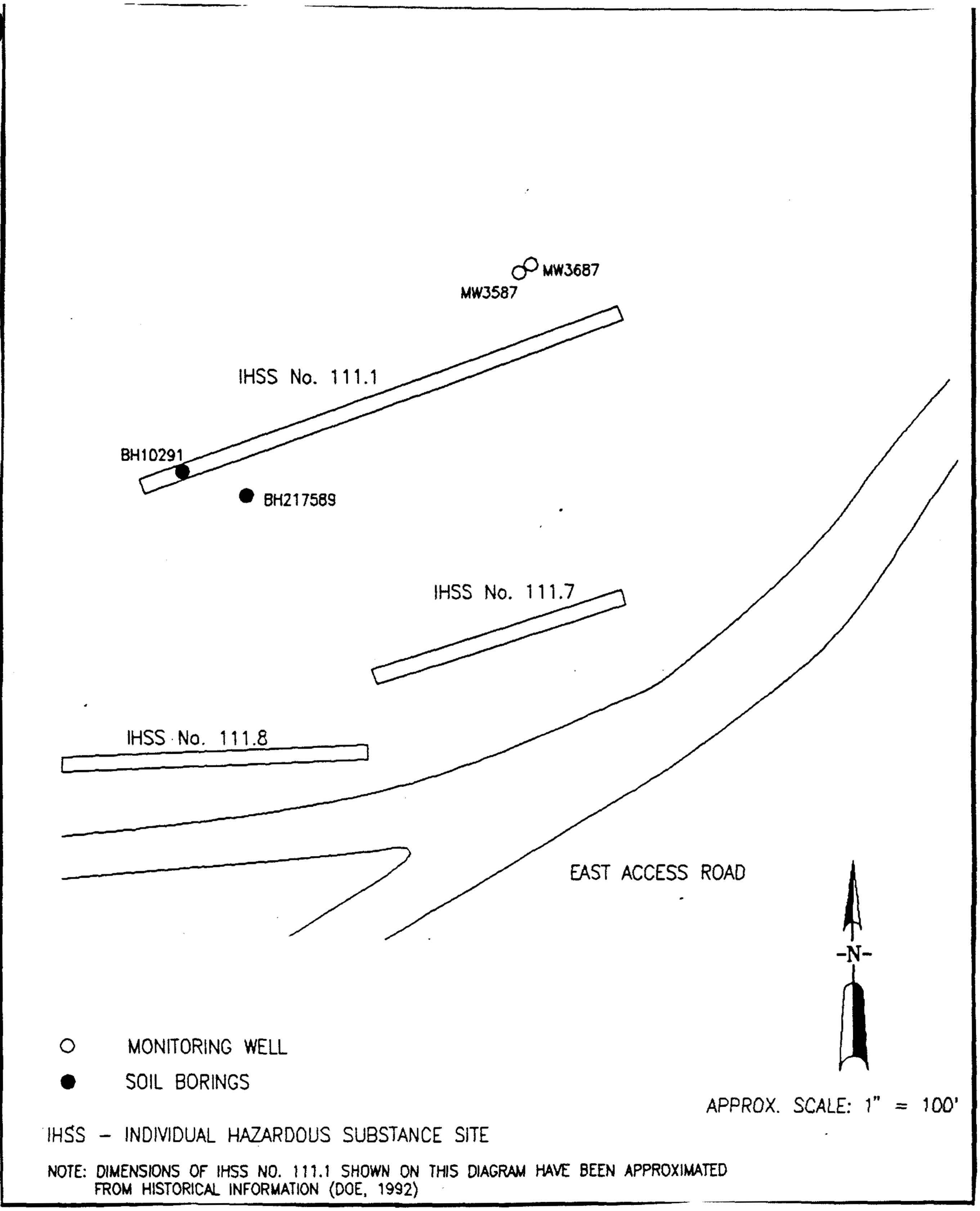
2.1.2 Historical Contaminant Release Information

A review of literature revealed little specific information about the historical use of any one disposal trench in the East Trenches Area. The available information described waste disposal practices at the East Trenches Area as a whole. To summarize, the burial trenches in this area were used between 1954 and 1968 for the disposal of sanitary sewer sludge contaminated with uranium and plutonium and approximately 300 flattened empty drums contaminated with uranium (Illseley, 1983). Based on a magnetometer survey, the proposed test site (T-4) is not expected to contain flattened drums. Although the radiation content of the sewage sludge disposed of in the East Trenches reportedly ranged from 382 picoCuries per gram (pCi/g) to 3,590 pCi/g (Owen and Steward, 1973), there are no reports of metallic nuclear materials deliberately buried in T-4. The only other material reportedly buried in T-4 is plutonium- and uranium-contaminated asphalt planking from the solar evaporation ponds (Illseley, 1983).

2.1.3 Soils and Bedrock

2.1.3.1 Lithology

One exploratory boring (Boring No. 10291) has been advanced through T-4 as part of the OU2 Phase II RI (Figure 2-1). Boring 10291 is located approximately 25 feet east of the western end of the trench. The geologic log for boring 10291 indicates sandy gravel alluvium to a depth of 18 feet. The alluvium is underlain by silty sandstone to a depth of 34 feet which is underlain by interbedded sandstone, silty sandstone, sandy siltstone and an occasional layer of claystone



1) **Figure 2-1 Soil Boring and Monitoring Well Locations (IHSS No. 111.1)**

(interbeds are on the order of 5 feet in thickness). This interbedded interval is primarily sandstone and extends from 34 feet to at least 60 feet, which is the total depth of boring 10291. Lithologies beyond the total depth of boring 10291 were extrapolated from a deeper boring (No. B217589) drilled in 1989 approximately 50 feet southeast of boring 10291. The log of this boring describes the interval between 60 and 160 feet as primarily claystone. An idealized conceptual geologic model based on the logs of boreholes 10291 and B217589 is presented as Figure 2-2. Boring logs are presented in Appendix C.

2.1.3.2 Volatile Organic Contaminants

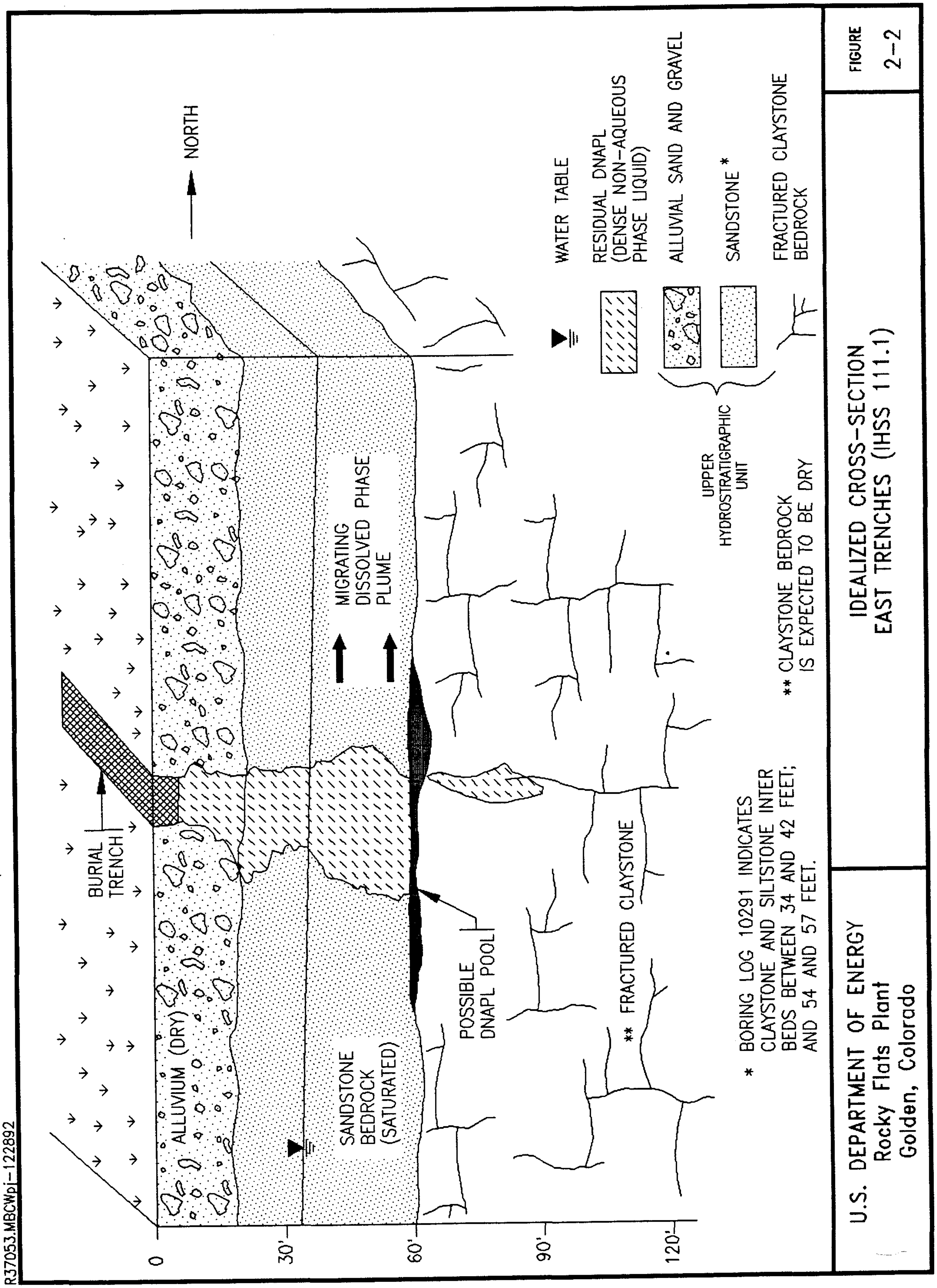
A review of preliminary soil chemistry data collected during the Phase II RI revealed the presence of tetrachloroethene (PCE) and trichloroethene (TCE) at 12.0 and 1.0 milligrams per kilogram (mg/kg), respectively, in a sample collected from 3 feet below ground surface during the advancement of boring 10291. The concentration of these contaminants decreased rapidly with depth. Because only one soil boring was advanced through T-4, the absence of high concentrations of VOCs in soil samples collected from this borehole does not preclude the presence of high concentrations in other portions of the trench.

2.1.4 Ground Water

2.1.4.1 Hydrogeology

Based on the log of boring 10291 and historical ground-water level data from monitoring well 3687 (located just north of T-4), unconfined ground water is expected to be encountered at approximately 35 feet below ground surface in the sandstone. Ground-water flow in the bedrock is generally towards the east/northeast in the vicinity of T-4. No ground water is expected to be present in the alluvial materials in the vicinity of T-4 based on historical water level data from alluvial monitoring well No. 3587 (Figure 2-1). Well 3587, located immediately

2) FIGURE 2-2 Idealized Cross-Section, East Trenches (IHSS No. 111.1)



NORTH
WATER TABLE
RESIDUAL DNAPL (DENSE NON-AQUEOUS PHASE LIQUID)
ALLUVIAL SAND AND GRAVEL
SANDSTONE *
FRACTURED CLAYSTONE BEDROCK
UPPER HYDROSTRATIGRAPHIC UNIT
ALLUVIUM (DRY)
SANDSTONE BEDROCK (SATURATED)
MIGRATING DISSOLVED PHASE PLUME
BURIAL TRENCH
POSSIBLE DNAPL POOL
** FRACTURED CLAYSTONE
0
30'
60'
90'
120'
* BORING LOG 10291 INDICATES CLAYSTONE AND SILTSTONE INTER BEDS BETWEEN 34 AND 42 FEET; AND 54 AND 57 FEET.
** CLAYSTONE BEDROCK IS EXPECTED TO BE DRY
IDEALIZED CROSS-SECTION
EAST TRENCHES (IHSS 111.1)
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado
FIGURE 2-2
R37053.MBCWpi-122892

adjacent to bedrock monitoring well 3687, has been dry for approximately 4 years. Boring logs for wells 3587 and 3687 are presented in Appendix C.

2.1.4.2 Volatile Organic Contaminants

Based on the description of historical waste disposal activities at the East Trenches Area (EG&G, 1992b) significant concentrations of VOCs would not be expected at T-4. However, ground-water samples from a bedrock monitoring well in the vicinity of T-4 (well 3687) contained elevated concentrations of chlorinated solvents, including TCE, carbon tetrachloride, chloroform, PCE, and 1,1,1-trichloroethane (TCA). Well 3687 is screened in the sandstone bedrock and is located approximately 40 feet northwest of the eastern end of T-4.

During the period November 1987 through August 1991, ground-water samples collected from bedrock monitoring well 3687 contained TCE at concentrations between 2.5 milligrams per liter (mg/ℓ) to 221.9 mg/ℓ. An August 1991 ground-water sample contained 68.0 mg/ℓ of TCE. The solubility of TCE in water is 1,100 mg/ℓ at standard temperature and pressure. The high TCE concentration of 221.9 mg/ℓ, which represents 20 percent of the TCE solubility limit, may indicate the presence of residual, free-phase TCE in the soils or bedrock underlying Trench T-4. The term "residual" refers to non-aqueous contamination remaining in the subsurface (by capillary force) subsequent to natural soil flushing. In addition, the downward migration of TCE through the saturated zone may have resulted in isolated pockets of more highly contaminated soils, or in some instances, dense non-aqueous phase liquid (DNAPL) trapped in structural depressions on the bedrock surface. DNAPL may also be perched on well cemented zones within the sandstone beneath T-4.

Other VOCs with historical concentrations at well 3687 greater than 1 mg/ℓ include carbon tetrachloride (1.6 mg/ℓ), chloroform (2.8 mg/ℓ), and PCE (2.4 mg/ℓ). Methylene chloride and acetone were also detected at concentrations greater than 1 mg/ℓ, however, methylene chloride and acetone were also detected in the sample blanks and are accepted as common laboratory contaminants. Ground-water analytical data for VOCs in ground water from monitoring well 3687 is summarized in Table 2-1.

2.2 IMPLEMENTATION OF SOIL VAPOR EXTRACTION AT EAST TRENCHES AREA

SVE is a relatively new technology that offers an alternative to the conventional excavation, treatment, and disposal approach. SVE removes volatile contaminants from the subsurface by mechanically drawing air through vadose zone strata pore spaces. VOCs, present in the "free phase" or dissolved in soil pore water will diffuse into soil gas and reach equilibrium concentrations proportional to the vapor pressure and Henry's Law constant for the particular compound. Under static conditions, there is little driving force to change the equilibrium conditions of the system comprised of VOCs, air, and water. However, the introduction of air flow within the subsurface profoundly disturbs the equilibrium conditions. The air flow carries away the gaseous VOCs preventing the development of equilibrium conditions between the free-phase and dissolved-phase VOCs and soil gas. This serves to maintain a high driving force to reach equilibrium in the vapor phase due to the relatively high concentration of solvent. In addition, contaminant volatilization kinetics are enhanced at lower pressures that are typically achieved adjacent to the extraction vent. The extraction vents are connected to a blower system which draws the contaminant-laden air stream to the surface. The extracted air stream may then be treated for removal of contaminants prior to discharge to the atmosphere.

SVE has been demonstrated as an effective remedial technology for removal of volatile contaminants from unsaturated zone strata (EPA, 1991b). As a result, SVE has become an established technology for remediation of vadose zone strata contaminated with volatile constituents. The effectiveness of SVE for remediating VOC-contaminated strata is generally governed by site-specific conditions, such as volatility of the contaminants and permeability of the contaminated strata.

3) Table 2-1 Groundwater Analytical Data for VOCs from Well 3687

Table 2-1

Rocky Flats Plant - IHSS 111.1 (Trench T-4)
Groundwater Analytical Data for VOCs from Well 3687
(ug/L)

Parameter	Sampling Date	9-Mar-88	4-May-88	19-Aug-88	10-Nov-88	15-Feb-89	8-May-89	11-Sep-89	10-Nov-89
1,1,1-Trichloroethane					8	63		200	
1,1,2-Trichloroethane									
1,1-Dichloroethane								6	
1,1-Dichloroethene			230		506	32	22 J	150	
1,2-Dichloroethane								2 J	
1,2-Dichloroethene					92				
2-Hexanone		975						8 J	
2-Butanone								9 J	
4-Methyl-2-pentanone									
Acetone			11					190	
Benzene								1 J	
Bromodichloromethane									
Carbon Tetrachloride		545		37	1,611	620	610	550	
Chloroform		1,370	2,810	56	486	270	290 E	1,300	
Methylene Chloride								19	
Tetrachloroethene			2,450	34	396	260	350 E	520	
Toluene							2 J	13	
Trichloroethene		131,820	221,860	71,150	2,451	49,000	12,000	110,000	18,000

NOTES :

B : Analyte also detetected in sample blank.
D : Diluted sample.
E : Estimated Value.
J : Analyte present below detection limit.

No entry in data table indicates analyte was not detected.

4) Table 2-1 Groundwater Analytical Data for VOCs from Well 3687, continued

Table 2-1 (Cont.)

Rocky Flats Plant - IHSS 111.1 (Trench T-4)
Groundwater Analytical Data for VOCs from Well 3687
(ug/L)

Parameter	Sampling Date	5-Mar-90	5-Jun-90	29-Aug-90	12-Nov-90	8-Mar-91	19-Apr-91	23-Aug-91
1,1,1-Trichloroethane			130			140		130
1,1,2-Trichloroethane						5		
1,1-Dichloroethane			3 J			4 J		
1,1-Dichloroethene			67			63		57 J
1,2-Dichloroethane						2 J		
1,2-Dichloroethene			42			60		40 J
2-Hexanone								
2-Butanone								
4-Methyl-2-pentanone			8 J			10		
Acetone		860 JB	16 B	4,100 JB		37 B		25 JB
Benzene								
Bromodichloromethane						1 J		
Carbon Tetrachloride		410 J	770	940 J	470 J	770 D	800	870
Chloroform		610 J	850	1,100 J	540 J	930 D	350	840
Methylene Chloride		1,600 B	19 B	1,400 JB	1,600 B	14 B		27 J
Tetrachloroethene		490 J	610	1,100 J	440 J	610 D	470	770
Toluene			5			10 B		
Trichloroethene		47,000 B	57,000	96,000	39,000	45,000 DE	38,000 D	68,000 D

NOTES :

B : Analyte also detetected in sample blank.
D : Diluted sample.
E : Estimated Value.
J : Analyte present below detection limit.

No entry in data table indicates analyte was not detected.

East Trenches soil characteristics indicate that the suspected residual contamination underlying T-4 is amenable to treatment by SVE. TCE, PCE, carbon tetrachloride, and chloroform all have Henry's law constants greater than 0.01, and thus, all have sufficient volatility to be removed by SVE (EPA, 1991b; Hutzler et al., 1989).

A major advantage of SVE as a remedial technology for the East Trenches Area is that remediation of VOC-contaminated strata would be conducted *in situ*. Remedies that minimize disturbance of vegetation and soils are preferable to those requiring excavation.

2.3 ANALYTICAL DATA QUALITY OBJECTIVES

Analytical data quality objectives (DQOs) are related to the objectives of the sampling and analyses program. The primary objective of the sampling and analysis program described in Sections 4 and 7 is to measure the instantaneous contaminant mass recovery rate of the SVE system and how the mass recovery rate changes with time and system configuration. Secondary objectives include measuring the effectiveness of the off-gas treatment equipment, characterization of the pumped ground-water waste stream, and characterization of soil samples collected during the drilling for vapor extraction wells.

Related DQOs associated with tolerances on field measuring equipment (pressure gauges, temperature indicators, etc.) are described in Section 6.7.

DQOs express quantitative and qualitative statements describing the quality and quantity of data required for the SVE system operation and testing. Developing DQOs relies on the following three stage process:

- Stage 1 - Identify decision types
- Stage 2 - Identify data uses/needs
- Stage 3 - Design a data collection program

2.3.1 Identifying Decision Types

The Subsurface IM/IRA Plan (EG&G, 1992b) and Section 1 of this document identifies the goals of the IM/IRA and the critical decisions to be made during implementation of the IM/IRA. Specifically, analytical data will be used to determine success or failure of the SVE pilot test, to evaluate the effectiveness of the off-gas treatment system, and to determine whether recovered ground water meets the influent requirements for the South Walnut Creek water treatment facility at RFP.

2.3.2 Identifying Data Users/Needs

Data users and needs are comprised of the following specific elements:

- Data uses
- Data types
- Data quality needs
- Data quantity needs
- Analysis options
- Precision, accuracy, representativeness, completeness and comparability (PARCC) parameters.

Table 2-2 describes these elements for each type of environmental media.

Table 2-2 Data Needs to Fulfill Pilot Test Objectives

Table 2-2, continued

Table 2-2

Data Needs To Fulfill Pilot Test Objectives

	ISV Off-Gas	Exhaust Gas Sample Filter Media	Soil	Ground Water
Data Uses:	To identify contaminant mass recovery rate and effectiveness of off-gas treatment equipment.	To verify that alpha emitting radionuclides are not present in exhaust gas.	To establish pre-treatment (baseline) contaminant concentrations.	Characterize extracted ground water and assess applicable RFP treatment facilities.
Data Types:	Chemical type and concentration; Collection and analysis of samples of extracted soil gas and treated soil gas.	Field measurement of exhaust gas sample filter media for alpha activity.	Chemical type and concentration. Collection of discrete and composite soil samples during drilling for vapor extractable wells.	Chemical type and concentration - collection of grab samples from water storage tank.
Analytical Parameters:	Trichloroethylene, perchloroethylene, carbon tetrachloride	Alpha activity	VOCs and Radionuclides[a]	EPA Target Compound List (VOCs) Target Analyte List and[b] Radionuclides[c]
Data Quality Needs:	Level II	Level II	Level III or IV	Level III or IV
Data Quantity Needs:	As Specified in Section 7	As specified in Section 7	As specified in Section 4	As specified in Section 6
Analysis Options:	Field or laboratory quality gas chromatograph with photoionization and electron capture detector (or detector with equivalent performance).	Benchtop laboratory alpha detector.	See footnote [d]	See footnote [d]
MDL:	20 ppbV for all analytes	≥ 20% detection efficiency (of Alpha present)		
Precision:	Laboratory replicate with < 20% RPD	NA		
Accuracy:	Initial 3 point calibration curve covering the range of the instrument detector with < 20% RSD. Calibration check every 12 hours at the mid point of the calibration curve with < 30% RPD from established response factor Laboratory method blanks with < 1/2 MDL	Daily calibration check against an alpha standard with < 40% RPD.	See footnote [d]	See footnote [d]

Table 2-2 (Continued)

Data Needs To Fulfill Pilot Test Objectives

	ISV Off-Gas	Exhaust Gas Sample Filter Media	Soil	Ground Water
Representativeness:	Sampling and analyses conducted in accordance with procedures presented in Section 7.	Sampling and analyses conducted in accordance with procedures presented in Section 7.		
Completeness:	Laboratory completeness > 70% Field data/sampling completeness > 80% Overall data completeness > 70%	Field Sampling > 70% Overall completeness > 70%	See footnote [d]	See footnote [d]
Comparability:	NA. Non-standard analytical method.	NA. Non-standard analytical method.		

[a] See Section 4 for appropriate analytical methods.
[b] Includes 5 non-TAL constituents: cesium, lithium, molybdenum, strontium, and tin.
[c] Gross Alpha; Gross Beta; Strontium 89, 90; Plutonium 239, 240; Americium 241, Tritium and Total Uranium 233/234, 235, 238
[d] See EG&G Rocky Flats General Radiochemistry and Routine Analytical Service Protocol (GRRASP) (EG&G, 1990) and Rocky Flats Site-Wide Quality Assurance Project Plan (EG&G, 1991).

NA = Not Applicable
ppbV = parts per billion (volume basis)
RPD = Relative Percent Deviation
RSD = Relative Standard Deviation (n-1)
MDL = Method Detection Limit

eg&g\ss-irap\etrench\2final\tbl_2-2.ian

Project Manager

Quality Assurance Program Manager

SECTION 3
DESIGN BASIS

3.1 INTRODUCTION

The SVE treatability study described in this Pilot Test Plan will determine whether SVE can be implemented to effectively remove suspected subsurface VOC contamination in vadose and saturated zone soils at the East Trenches Area of OU2. In addition to the soil VOC contamination, the presence of free-phase VOCs is suspected in the vadose and saturated zone beneath the trenches. Although the exact location of the test site has not been finalized, the western end of T-4 has been arbitrarily selected as the study area. Therefore, the design information presented in following sections utilizes the western end of T-4 as the test site (Drawing Nos. 1 and 2, see Appendix A).

This section provides the basis for the pilot SVE system design at the western end of T-4 as well as detailed information such as soil characteristics and ground-water chemistry data, which form the basis for the design. Design and equipment specifications are presented in Sections 4 through 6.

It should be noted that the selection of the western end of IHSS No. 111.1 (T-4) is tentative and completely arbitrary. The actual locations of the SVE vent wells will be selected based on forthcoming soil vapor survey and Phase II Alluvial RI data. The final test site selection will be made by EG&G-Rocky Flats, Inc. An arbitrary selection for the location of the pilot test at IHSS No. 111.1 was made to expedite the preparation of the document (i.e., site plan map).

Once the final test site location is determined, the design considerations presented herein will be revisited to determine if any design modifications are necessary.

3.2 TRENCH T-4 PILOT SYSTEM DESIGN

3.2.1 Introduction

Evaluation of site history and characteristics is essential prior to designing and operating an SVE system. Other site conditions such as local geology, hydrogeology, and climate contribute valuable information when assessing contaminant migration pathways and rates, in addition to influencing the design and performance SVE systems.

Soil characteristics such as permeability, particle size distribution, and moisture content determine whether sufficient subsurface air flow can be achieved to allow for contaminant removal. In addition, subsurface air flow is influenced by the heterogeneous nature of the soil and the presence of subsurface features. Such features influence air and contaminant movement pathways, sometimes making it more difficult to optimize extraction vent and pressure monitoring (PM) probe locations. For example, the trenches being investigated have had heterogeneous materials placed in them prior to backfill. The backfilled soil is generally loosely packed and less restrictive to flow, and hence may result in preferential flow pathways or conduits, while the buried materials in the trenches may provide obstructions to air flow.

SVE can also be used to remove contaminants from vadose zone bedrock. Bedrock characteristics such as surface slope, fracture properties, and hydraulic conductivity must be considered when designing a bedrock system. Soluble contaminant migration is greatly influenced by ground-water movement. Movement of ground water through a bedrock system is controlled by the orientation and the degree of connection of joint and fracture sets and/or intergranular porosity (primary and/or secondary). The porosity and fracture system distribution may be heterogeneous; therefore, the properties of the water-bearing bedrock may vary with location and depth. In addition, undulations and other small scale topographic features on the bedrock surface may result in isolated pockets of more highly contaminated soils, perched ground water, or DNAPL trapped at the alluvial/bedrock interface.

The components of soil venting systems are typically "off-the-shelf" items. However, design of such a system is site-specific. Design specifications such as the number of vents, vent spacing, vent location, vent construction, and vapor treatment are often determined by a combination of design formulas, practical experience, and best engineering judgement. The vapor extraction unit (the blower and associated equipment that provides the necessary pressure differential) is shown in Drawing No. 11.

3.2.2 Expected Conditions at Trench T-4

A discussion of expected hydrogeologic and contaminant characteristics was presented in Subsection 2.1, and a more thorough discussion was presented in the Subsurface IM/IRA Plan (EG&G, 1992b). The following discussion summarizes the site characteristics with respect to subsurface and above-ground SVE system design criteria.

The VOCs expected to be present at T-4 include TCE, PCE, TCA, chloroform and carbon tetrachloride. However, based on inferences made about nearby ground-water chemistry, only TCE is expected to occur as a free-phase solvent and, therefore, will be the primary target contaminant for the SVE. The location or actual presence of free-phase VOCs is not known and may or may not be encountered by the pilot system.

The hydrogeology of the test site is expected to consist of unsaturated, unconsolidated, sandy gravel alluvium from the surface to a depth of 18 feet. The alluvium is underlain by silty sandstone to a depth of 34 feet which is underlain by interbedded sandstone, silty sandstone, sandy siltstone and an occasional layer of claystone (interbeds are on the order of 5 feet in thickness). This interbedded interval is primarily sandstone and extends from 34 feet to at least

60 feet with ground water present at approximately 35 feet. Below 60 feet, claystone is expected to be present.

There are technical difficulties associated with the design and implementation of an SVE system in this area due to the paucity of quantitative data on soil and bedrock conditions at T-4. Although not anticipated, subsurface features such as buried drums may be present in T-4, and, if present, would be expected to influence air flow pathways. In addition, the backfilled soil used to cover T-4 is expected to be loosely packed and hence more permeable and less restrictive to flow than surrounding undisturbed soils. Therefore, subsurface air flow pathways may be difficult to predict and control. In addition, since little analytical data currently exist on VOC concentrations in the soil at T-4, it is undetermined if sufficient quantities exist that would warrant the utilization of SVE. The results of a proposed soil vapor survey will help to make this determination.

3.2.3 Extraction Vents

The permeability of the soils, as it relates to the design parameter known as the radius of influence, affects the number and location of the extraction vents in a multiple extraction vent SVE system. The radius of influence is defined as the distance from the extraction vent at which the subsurface pressure equals atmospheric pressure (no longer negative pressure). Typically, this implies that all soils within this radius of influence will be subject to treatment. Therefore, to approximate the number of vents necessary to treat a target area using an SVE system, the radius of influence for a vent should be evaluated.

In determining the positioning of vapor extraction vents, it is desired to maximize vapor flow through the contaminated zone while minimizing it through other zones. If only one vent is used, it is usually placed in the center of the contaminated zone. Thus, all air flowing into the vent will sweep through the contaminated region. When placement of the vent directly into the contaminated region is not possible, an alternate location is chosen that maximizes air flow through the effected soils.

The precise location of the extraction vents will be determined based on the results of a soil vapor survey to be conducted along the perimeter of T-4 (EG&G, 1992a). However, for the purpose of this document, the SVE vents are tentatively proposed to be installed near the west end of T-4. The western end of T-4 was arbitrarily selected.

Soil boring 10291 (presented in Appendix C), which is the only boring through T-4, describes alluvium to a depth of 18 feet below ground surface (bgs) with silty sandstones directly beneath the alluvium to a depth of 60 feet bgs. Although the geology can be expected to vary laterally, these materials are believed to be generally representative of the geology underlying all of T-4.

As shown in Drawing Nos. 1 and 2 (presented in Appendix A), the pilot SVE system at T-4 will consist of two vertical vapor extraction vents installed 20 to 25 feet east of the western end of T-4. One vent will be constructed in the alluvium, while the other will be constructed in the sandstone. In addition, the extraction vents will be placed on the northern side of the trench since local ground water, which flows to the east/northeast, may have influenced contaminant migration towards the east/northeast. The extraction vents are placed 5 feet apart from each other to minimize the influence of one vent on the other when both are in operation. The vents are placed close to the northern side of the trench (2 to 3 feet) which minimizes the risk of drilling into the trench, while still maintaining a close proximity to the trench. Because materials were buried in T-4, and historical records of material type may be incomplete, drilling through the trench itself will not be attempted.

The screened interval of the extraction vent will extend from approximately 9 to 18 feet in the alluvium (see Drawing No.3), with an additional 2 feet of screened interval in the sandstone. The alluvium screened interval was chosen to cause the extraction vent to draw air underneath the trench, where contamination due to trench leakage would be expected. It is also anticipated that the vent will draw air from the surface (i.e. non-radially) and sweep through the trench. The screened interval starts at 9 feet (instead of less than 9 feet) to prevent air from being drawn directly from the borehole/alluvium interface (also known as short-circuiting). The alluvium extraction vent will be installed approximately 2 feet into the sandstone underlying the alluvium. This will allow the vent to extract any free-phase liquid trapped at the alluvium/sandstone interface.

As shown in Drawing No. 5, the sandstone extraction vent will penetrate into the sandstone to allow for the collection and recovery of free-phase or perched DNAPL should it be encountered in the sandstone. The screened interval of the extraction vent will extend from approximately 22 feet bgs to 5 feet below the sandstone/claystone interface. A surface casing will be provided to prevent the migration of contamination from the alluvium. A submersible ground-water pump will be installed to lower the water table and expose contamination in the saturated zone. The vent will be installed approximately 5 feet into the claystone to allow the vent to extract any free-phase liquid trapped at the sandstone/claystone interface.

3.2.4 Pressure Monitoring (PM) Probes

The radius of influence of the individual extraction vents is determined by measuring subsurface negative pressures. PM probes facilitate measurement of subsurface pressure at varying distances from the extraction vents. PM probes are slotted drive points similar to piezometers.

Multiple PM probes are typically installed at varying distances from the extraction vents (5, 10, 20 feet, etc.) to evaluate the radius of influence. Once subsurface pressure data is collected, a theoretical estimate of the radius of influence can be obtained using the steady-state radial pressure distribution equation (Johnson et al., 1990):

$$P^2(r) = (P^2_{ATM} - P^2_w)\frac{\ln(r/R_W)}{\ln(R_I/R_W)} - P^2_W$$

where:

- $P(r)$ = the absolute pressure measured at a distance r from the operating vent
- P_{ATM} = absolute ambient pressure
- P_W = absolute pressure applied at the vapor extraction vent
- R_W = radius of the vapor extraction vent
- R_I = radius of influence of the vapor extraction vent

It should be noted that this equation assumes steady-state radial flow and does not account for surface leakage.

This equation indicates that just a single PM probe would be required to determine the radius of influence. In practice, however, steady-state radial flow (and therefore pressure) is often not achieved. Therefore, multiple pressure monitoring points give a more accurate picture of the pressure distribution profile. In these instances, a plot of the subsurface pressure as a function of distance from the extraction vent can be utilized. Thus PM probes are spaced away from the extraction vent to facilitate both theoretical and actual data evaluation.

PM probes will be installed at various distances away from the extraction vents to monitor subsurface pressure. Their locations are shown on Drawing Nos. 1 and 2, and construction details are presented on Drawing Nos. 7 and 8. Alluvial PM probes will be located at distances of 5, 15, and 20 feet away from the alluvial extraction vent, while sandstone PM probes will be located at distances of 5 and 13 feet away from the sandstone extraction vent. In addition, the forced air injection vents (described in Subsection 3.2.5) will serve as PM probes when not in operation as air injection vents, resulting in added PM probes located at distances of 10 and 8 feet away from the alluvial and sandstone extraction vents, respectively. These selected distances will allow for the measurement of subsurface pressure in individual strata as a function of distance from the respective extraction vent at various air flow rates. Individual strata subsurface pressure distributions measured during startup tests can then be compared to the steady-state radial pressure distribution equation presented in Subsection 3.2.2, to determine if steady-state radial flow was achieved in the alluvium and the sandstone. If steady-state radial flow is not achieved, the measured pressure distributions can be used to estimate the radius of influence by evaluating the subsurface pressure as a function of distance from the extraction vent.

The distances of the PM probes (away from the extraction vent) were selected to provide several data points for this analysis, and will be valid over a wide range of radius of influences (10 feet to 40 feet). The specific distances were selected based on best engineering judgement. To minimize the volume of cuttings generated during installation, only two sandstone PM probes are to be installed. A sandstone PM probe was not installed at 20 feet. It is reasonable to not install this PM probe because of the expected lower air permeability in the sandstone.

Another factor considered when selecting PM probe locations included the preference for enhanced air flow control. PM probes may be used as passive ambient air inlets. Passive air inlets may allow for improved air flow rates and improved flow control which can result in more efficient contaminant removal. For instance, the use of PM probes on the southern side of T-4 as ambient air inlet vents will allow for increased air flow through and under T-4 toward the extraction vents. The use of PM probes as ambient air inlets will be evaluated by utilizing the forced air injection vents as passive air inlets during pilot testing; the pilot tests will also permit a direct comparison between the effectiveness of passive and forced air inlets and their impact on SVE system performance.

During air injection periods, surrounding PM probes will monitor subsurface pressure to confirm that the injected air is being withdrawn at the extraction vent. Specifically, the subsurface pressure at PM probes adjacent to the air injection vents will be monitored and maintained at or below atmospheric pressure during air injection periods, thereby ensuring that contaminants are not forced away from and out of the radius of influence of the respective extraction vent. Therefore, a PM probe will be located at a distance of 5 feet from the air injection vent, in a straight line away from the extraction vent.

The depth of the slotted section of the alluvium PM probes will be approximately 2 feet above the alluvium/sandstone interface, and the length will be 3 feet. The slotted section is positioned to correspond to the bottom portion of the extraction vent because there is a better chance for radial flow the further away it is from ground surface. Three feet of slotted section is specified to provide a large open interval if the probes are used for passive air inlet. Sandstone PM probes are slotted corresponding to the entire length of the sandstone extraction vent because radial flow can be reasonably expected at the depths involved.

3.2.5 Air Injection Vents

An SVE system can include vents that allow air to be injected into the soil. An air injection vent utilizes a blower to force heated or ambient temperature air into the soil. It is anticipated that forced air injection vents may improve subsurface air flow and VOC removal rates. Specifically, the injection of air will result in increased pressure gradients towards the extraction vents, thereby inducing greater flow rates to the extraction vents. Forced air injection vents must be located at a close enough distance from the extraction vent so as not to force contaminated vapors away from the extraction vents. In addition, forced air injection rates must be conservatively chosen to ensure that contaminated vapors are not driven away from the extraction vents.

The pilot SVE system will include one forced air injection vent for the alluvium and one for the sandstone. The construction details of the air injection vents are presented on Drawing Nos. 4 and 6. The forced air injection vents will be located on the southern side of T-4, opposite to their respective extraction vents, to create preferential air flow pathways which sweep beneath the trench toward the extraction vents.

The depth and slotting requirements of the alluvium air injection vent were chosen to maximize the volume of soil affected by air injection. The slotting requirements match those of the alluvium extraction vent such that all alluvium soils between the injection and extraction vents can be treated. The sandstone injection vent depth and slotted interval were chosen on the same basis. As discussed in the Subsurface IM/IRA Plan (EG&G, 1992b), the sandstone injection vent is equipped with a submersible ground-water pump to lower the water table while providing a pathway for air to sweep through the previously saturated sandstone.

3.2.6 Blower

The sizing of the blower for an SVE system is performed after determining the number of extraction vents and their associated screened intervals. The required vapor flow rate can be determined using the formula (Johnson et al., 1990):

$$Q = \frac{H \pi k P_W}{\mu} \frac{[1-(P_{ATM}/P_W)^2]}{\ln(R_W/R_I)}$$

where:

- Q = flow rate
- k = soil permeability factor
- μ = air viscosity
- P_W = absolute pressure applied at the vapor extraction vent
- P_{ATM} = absolute ambient pressure
- R_W = radius of the vapor extraction vent
- R_I = radius of influence of the vapor extraction vent
- H = Σ screened intervals for all vents

This equation is derived from the steady-state radial flow solution for compressible flow. By knowing or estimating the soil permeability and the radius of influence, the vapor flowrate can be estimated thus providing an estimate for proper blower size. In the absence of air permeability and radius of influence data, a reasonable range of values and practical experience with SVE systems can be used to estimate the required air flow.

The blower specified for this study was designed to have sufficient capacity to accommodate all three proposed tests as presented in the Subsurface IM/IRA Plan (EG&G, 1992b). It is expected that the alluvium vents will provide the most air flow of all the formations to be tested in OU2. As shown in the IM/IRA Plan, the 903 Pad SVE system is expected to have approximately 35 feet of screened interval in the alluvium. To determine the flow rate per unit length (Q/H), a range of radius of influences (20 to 40 feet), air permeabilities (10 to 50 darcies), and pressures (1 to 3 inches of mercury [Hg]) were used. These input parameters were chosen based on past experience with SVE systems and site-specific knowledge. These calculations determined that a range of Q/H of 10 to 25 standard cubic feet per minute per treatment foot (scfm/ft) could be possible. Fifteen scfm/ft was used to accommodate a blower that could be trailer-mounted, and to utilize a reasonable portable power supply. Therefore, the air flow rate of the blower will be approximately 600 cfm (35 treatment feet * 15 scfm/ft and adjusted to account for 3 inches Hg). These calculations are presented in more detail in Appendix E.

Furthermore, a negative pressure of 17 inches Hg was chosen as the pressure differential that should be achievable by the blower to achieve 14 inches Hg pressure differential at the extraction wells. The rationale and calculations for the blower sizing are presented in more detail in Appendix E.

The blower configuration for the pilot test is shown in Drawing No. 11. As seen on this drawing, a two-stage blower will be utilized. A two-stage blower configuration is specified for several reasons. First it allows positive displacement blowers to be used to achieve the head pressures that might be required in tight formations to achieve air flows. Positive displacement blowers are preferred for many SVE applications because the air flow rate does not vary significantly over the blower's operating range. Second, the power requirements of a dual-stage blower configuration are less than for a single-blower system. Because each blower in a dual blower configuration handles less than the full pressure load, the blowers operate in a higher efficiency range. Third, all untreated vapor is handled in the vents, manifold, and vapor treatment system under negative pressure (less than atmospheric), reducing the risk of potential uncontrolled leaks or releases. Finally, higher carbon efficiencies are possible by reducing the relative humidity of the extracted air, since adsorbed water will reduce the carbon capacity.

3.2.7 Vapor Treatment

Pilot SVE systems are generally designed to utilize vapor-phase GAC for vapor treatment. Activated carbon can be used to treat most vapor streams but is most economically efficient for low contaminant concentrations when compared to other vapor treatment technologies. GAC efficiency for a given compound is affected by many factors including temperature, pressure, relative humidity, and contaminant concentration. Maximum efficiency is achieved under low temperature, high pressure, low relative humidity, and high concentration conditions. Unfortunately, it is difficult to control all these competing factors, so operational experience is required to maximize carbon efficiency while maintaining high contaminant removal rates. Other potential types of vapor treatment include catalytic oxidation or vapor combustion units, however, these are best utilized for high vapor VOC concentrations or compounds that are not readily adsorbed by GAC.

A vapor phase activated carbon system will be used to remove VOCs from the extracted vapor stream. The activated carbon system will consist of two carbon bins in a series configuration between the two system blowers (Drawing No. 11). Each carbon bin will have inlet and outlet sampling ports to monitor contaminant removal efficiency and provide information when the lead carbon bin is spent or becomes saturated.

3.2.8 Ground-Water Extraction

SVE systems can cause an upwelling of a ground-water table in the vicinity of the vapor extraction vent. If the depth to ground water is shallow with respect to the vent, ground-water extraction may be necessary to suppress the ground-water table, thereby preventing water from being drawn directly into the vent and/or submersing the contaminated zone soils. Elsewhere, suppression of the ground-water table may be performed to increase the volume of vadose zone to be treated by SVE. Ground water can be extracted from the vapor extraction vent simply by installing a submersible ground-water pump into the vapor extraction vent; however, an air-tight surface seal must be provided for the ground-water extraction piping, power line, and controls to prevent unwanted short-circuiting (direct introduction of ambient air into the extraction vent) of the extraction vent.

The pilot SVE test at T-4 will include ground-water extraction from air extraction and air injection vents. As shown in Drawing No. 11, one pump will be installed in the sandstone extraction vent and one in the sandstone injection vent for a total of two recovery pumps. The purpose of ground-water extraction is to suppress the water table, which is expected to be encountered at approximately 35 feet bgs in the sandstone bedrock, hence increasing the volume of vadose zone to be treated by the pilot SVE system.

The design flow basis for recovered ground water is 5 gallons per minute. This value was derived (as shown in Appendix E) from preliminary pumping test data and an estimated drawdown in the pilot test well(s) no greater than 25 feet.

The pumping test performed on the "Arapahoe Sandstone" during the Phase II RI (conducted during the Spring of 1992) achieved 7.5 feet of drawdown at a constant pumping rate of 1.5 gallons per minute (gpm). This is equivalent to a hydraulic conductivity (K) of approximately 1.0 feet/day. However, it is important to note that the pumping test was conducted at a location approximately 200 feet east of the proposed SVE test site (T-4). Five gpm has been identified as a maximum pumping rate (based on considerations associated with transportation and treatment of the recovered water), and the amount of drawdown created will be controlled by this specified pumping rate.

Although the pumping schemes illustrated in the Subsurface IM/IRA Plan (EG&G, 1992b) show drawdown to the lower confining claystone, the actual drawdown induced in the vapor extraction vent will depend on the geology encountered and the actual ground-water extraction rate. The purpose of inducing drawdown is to expose VOCs retained in the sandstone below the water table and to subject them to treatment.

The cones of depression induced by pumping ground water from the sandstone vapor extraction and air injection vents should overlap resulting in a combined pumping rate of less than two times the pumping rate required to induce equivalent drawdown in a single well. In addition, more water will be extracted from the extraction vent than from the injection vent. The negative pressures within the extraction vent will raise the water table requiring a higher pumping rate than in the air injection vent in order to maintain similar dynamic water levels (assuming the geologic conditions and well yields are the same).

Extracted ground water will be collected at the pilot test site and subsequently transported to the South Walnut Creek Basin Surface Water Treatment Facility (EG&G, 1991a; see Section 5.3). The South Walnut Creek Basin Facility was selected as the preferred RFP water treatment facility to process potentially contaminated ground water collected during SVE pilot testing (EG&G, 1992b). The alternative RFP water treatment facilities considered may still be used, however. The alternative facilities include the 881 Hillside Groundwater Treatment Facility and the Building 231B GAC Adsorption (planned)/Building 374 Evaporation Systems. Use of these alternative facilities will be based on several factors including actual ground-water flow rates and contaminant profile obtained during pilot testing as well as the available processing capacity at each facility.

The rationale for selection of the South Walnut Creek Basin surface water treatment system is presented in subsection 4.3.2.1 of the Subsurface IM/IRA Plan (EG&G, 1992b). Ground-water flow rate and contaminant profile data will be collected early in the pilot test program to help guide this decision.

DOCUMENT MODIFICATION REQUEST (DMR)

Refer to 1-A01-PPG-001 for Processing Instructions.
***Print** or **Type** All Information (Except Signatures).*

1. Date: 11/9/94

25. DMR No. 94-DMR-ERM-0140 (initialed 11/14/94)

2. Existing Document Number/Revision: 21000-WP-OU2.07

3. New Document Number or Document Number if it is to be changed with this Revision: N/A

4. Originator's Name/Phone/Pager/Location: D. W. Pontius/8616/4620/080,651

5. Document Title: Final Pilot Test Plan Soil Vapor Extraction Technology Subsurface IM/IRA East Trenches Area (OU 2)

6. Document Type: ☐ Procedure ☒ Other ____

7. Document Modification Type (Check only one): ☐ New ☐ Revision ☐ Intent Change ☒ Nonintent Change ☐ Editorial Correction ☐ Cancellation

8. Item	9. Page	10. Step	11. Proposed Modifications
1	19	4.8.4	Add new subsection 4.8.4, "Field Activities to Support Remedial Design at OU 2"
2	After 19		After the added text of section 4.8.4, add new Table 1-1
3	After 19		After the added text of section 4.8.4, add new Figure 1-1

12. Justification (Reason for Modification, EJO #, TP #, etc.)

1-3. To characterize IHSS 110 in support of the SVE.

If modification is for a new procedure or a revision, list concurring disciplines in Block 13, and enter N/A in Blocks 14 and 15. If modification is for any type of change or a cancellation, organizations are listed in Block 13, then Concurror prints, and signs in Block 14, and dates in Block 15.

13. Organization	14. Print, Sign (if applicable)	15. Date (if applicable)
QS	R.S. Luker [signature]	11.9.94
OU 2 PM	P. J. Laurin [signature]	
SME	R. J. McLaughlin [signature]	

16. Originator's Supervisor (print/sign/date): P. J. Laurin [signature]

17. Assigned SME/Phone/Pager/Location	18. Cost Center	19. Charge Number	20. Requested Completion Date	21. Effective Date
R. J. McLaughlin/6995/080 [signature]	3112	989516	11-14-94	11/15/94

22. Accelerated Review? Yes ~~☒~~ No ☒

23. ORC Review: NOT REQUIRED

24. Responsible Manager (print,sign,date): W. S. Busby [signature] For W. S. Busby

REVIEWED FOR CLASSIFICATION / UCNI
BY ____
DATE ____

RF-47940 (5/93)

Project Manager

Quality Assurance Program Manager

SECTION 4

VAPOR EXTRACTION VENTS AND GROUND-WATER WELL SPECIFICATIONS

The objective of the pilot SVE test described herein is to provide information concerning the removal of residual VOC contamination from soils and bedrock to support FS evaluation of SVE as a remedial action alternative for subsurface contamination underlying the East Trenches Area. The pilot SVE system will include the following:

- alluvium extraction vent (1)
- alluvium forced air injection vent (1)
- sandstone extraction vent and ground-water extraction well (1)
- sandstone forced air injection vent and ground-water extraction well (1)
- alluvium PM probes (3)
- sandstone PM probes (2)

PM probes will be installed at various distances from the extraction vents to monitor subsurface pressure. PM probes will also be used as passive air inlets. Forced air injection vents, when not in operation, will also be used as PM probes and passive air inlets. Vapor manifold systems will be installed to connect the vapor extraction vents and forced air injection vents to their respective aboveground equipment.

The following subsections provide the construction and performance specifications for the aforementioned vapor extraction vents, forced air injection vents, ground-water extraction wells, PM probes, and associated vapor manifolds. The construction specifications presented herein are empirical in nature. Substitute construction specifications may be employed provided the operating requirements are met. Operating requirements, where appropriate, are also described. All referenced design drawings have been included in Appendix A.

It should be noted that the subcontractor providing the services described in this section will submit design drawings and design calculations to EG&G-Rocky Flats, Inc. for approval prior to purchasing any equipment and/or materials and prior to initiating any construction activities. EG&G approval of the submittals required by this Test Plan does not alleviate the subcontractor from the responsibility of providing a properly functioning pilot test system.

4.1 EXTRACTION VENTS - GENERAL SPECIFICATIONS

The typical extraction vent will consist of 4-inch inner-diameter well screen extended throughout the length of the treatment interval and centered within the borehole by a sandpack. The sandpack will allow air and ground water (where specified) to enter the vent, but will prevent any soil particles from entering the vent. This sandpack extends from the bottom of the borehole to 1 foot above the well screen section (i.e., the screened interval). The sandpack will be constructed of a sand with a sufficient nominal grain size so that sand will not enter the well screen. The lower end of the well screen will be sealed with an air-tight cap. The upper end of the well screen will be connected to a 4-inch inner-diameter riser pipe which will extend to a height 1 to 2 feet above ground surface. Directly above the sandpack (in the annulus around the riser pipe), a 1-foot layer of hydrated bentonite pellets will be emplaced, above which a cement/bentonite grout seal will be installed and brought to the ground surface. The bentonite layer will provide an air-tight seal to prevent short-circuiting of the vent (i.e., prevent leakage of air from the upper zone or from the atmosphere through the annular space and into the well screen), and will also prevent the overlying grout seal from flowing into the sandpack. All joints in the extraction vent will be threaded or chemically welded as required by the material of construction.

All vapor extraction/injection vents and PM probes installed in bedrock will be isolated from the alluvium using a surface casing. A borehole, 4 inches larger than the casing diameter (specified in subsections 4.1 and 4.3) will be advanced 2 feet into bedrock. The oversized borehole will allow for the surface casing to be grouted in place. Centralizers will be attached to the casing at 10-foot intervals (minimum of two sets of centralizers). The surface casing will be pressure grouted in place by raising the casing 2 feet off the bottom of the borehole and pumping grout down the center of the casing and up through the annular space until it rises to the surface. A rubber plug will be inserted in the surface casing and forced down to the bottom of the casing with water pressure (RFP SOP No. GT. 03). The grout will be allowed to cure for 24 hours, and the water in the casing will be removed before drilling resumes. Subsequent drilling will be performed through the surface casing, resulting in a bedrock borehole diameter no larger than the inner diameter of the surface casing.

Perform the development as soon as practical after well installation, but no sooner than 48 hours after grouting and pad installation is completed. New vent wells will be developed utilizing low-energy methods. The equipment of choice for well development is an inertial pump or bottom discharge/filling bailer. High-energy methods such as submersible pumps, surge blocks, overpumping, backwashing, and well jetting will not be used due to the possibility of formation fines clogging the well screen.

All newly installed wells will be checked for the presence of immiscible layers prior to well development. The method for detecting these layers in monitoring wells is discussed in SOP GW.1.

Water Level Measurements in Wells and Piezometers. If an immiscible layer of 5 mm or greater has been detected in a newly installed well, well development procedures will not continue until the EG&G project manager has been notified. In the case where an immiscible layer is not identified, a water level measurement will be taken according to SOP GW.1, Water Level Measurements, and well development activities will continue. The water level measurement along with the total depth measurement will be used to determine the volume of water in the well casing. Well casing calculations are presented in Subsection 5.2.1.1 of this SOP.

Formation water and fines will be evacuated by slowly lowering and raising the inertial pump or bailer intake throughout the water column. Criteria which indicate a fully developed well along with additional details of the development procedure are presented in RFP SOP No. GW.02. The inertial pump may be placed inside a decontaminated 1-inch diameter PVC pipe if the pump intake cannot be lowered to the bottom of the well. The PVC pipe will prevent the inertial pump intake from bending prior to reaching the desired depth. EG&G will determine whether an inertial pump will be dedicated to a specific well based on verified organic vapor detector (OVD) readings obtained during the drilling of the well. OVD readings are described in SOP FO.15, Photoionization Detectors and Flame Ionizing Detectors. If a bailer is used for well development, it will be used with a mechanical reel equipped with a stainless steel cable. Development equipment will be protected from the ground surface with clear plastic sheeting. Development equipment, including bailers and pumps, will be decontaminated before well development begins and between well sites according to SOP FO.3, General Equipment Decontamination. Following well development, a groundwater sample will be taken for laboratory analysis to identify groundwater sample characteristics (see subsection 7.3.4 for specific groundwater analytes).

Estimated recharge rates will be measured following the procedures outlined in SOP GW.1, Water Level Measurements in Wells and Piezometers. Decontamination and development water will be handled according to SOP FO.7, Handling of Decontamination Water and Wash Water, and SOP FO.5, Handling of Purge and Development Water, respectively.

Measuring points will be established on the riser pipe of all vents and PM probes. Horizontal and vertical control will be established on the measuring points to within 1.0 and 0.01 feet, respectively. Procedures associated with land surveying are described in RFP SOP No. FO.17.

Drawing Nos. 1 and 2 (see Appendix A) indicate the layout of the vents and probes for the alluvium and sandstone, respectively, in relation to the western end of T-4. The specific construction requirements for each of the individual extraction vents is discussed below. It should be noted that the typical air injection vent will be similar in construction to the typical extraction vent. Forced air injection rates were conservatively chosen not to exceed 50% of the vapor extraction rates to ensure that contaminated vapors will not be forced away from the extraction vents. During air injection periods, surrounding PM probes will monitor subsurface pressure to confirm that the injected air is being withdrawn at the extraction vent.

4.1.1 Alluvial Extraction Vent

Depth - The alluvial extraction vent will be constructed to a depth of 2 feet below sandstone surface. The screened interval will extend from 9 feet bgs to a depth of 2 feet below sandstone surface.

Construction/Performance Requirements - The alluvial extraction vent depth and construction requirements are illustrated on Drawing No. 3. As shown on Drawing No. 3, the alluvial extraction vent will be constructed to meet the following requirements:

- Quantity — (1) One.
- Orientation — Vertical.
- Piping Specifications — Well screen: 4-inch inner-diameter, 0.01-inch slot. Riser pipe: 4-inch inner-diameter.
- Borehole Diameter — 8-inch.
- Screened Interval — Top: 9 feet bgs. Bottom: 2 feet below sandstone bedrock surface.
- Extraction Rate — Variable, expected to be 10-15 scfm/ft of screened interval.

- Operating Pressure — 15-inch Hg negative pressure at the vent well head.

4.1.2 Alluvial Forced Air Injection Vent

Depth – The alluvial air injection vent will be constructed to the sandstone bedrock surface. The screened interval will extend from 9 feet bgs to the sandstone bedrock surface.

Construction/Performance Requirements – The alluvial air injection vent depth and construction requirements are illustrated on Drawing No. 4. As shown on Drawing No. 4, the alluvial air injection vent will be constructed to meet the following requirements:

- Quantity — (1) One.
- Orientation — Vertical.
- Piping Specifications — Well screen: 4-inch inner-diameter, 0.01 inch slot. Riser pipe: 4-inch inner-diameter.
- Borehole Diameter — 8-inch.
- Screened Interval — Top: 9 feet bgs. Bottom: sandstone bedrock surface.
- Injection Rate — 10 - 50% of the extraction rate of the alluvial extraction vent.
- Operating Pressure — Maximum: 5 pounds per square inch (psi) at air injection blower.

4.1.3 Sandstone Extraction Vent

Depth – The sandstone extraction vent will be constructed to a depth of 5 feet below claystone surface (if encountered), and a minimum of 50 feet bgs or a maximum of 90 feet bgs. Claystone surface will be defined as the first continuous claystone bedrock interval, as indicated by 5 consecutive feet of claystone, encountered below 50 feet bgs. The screened interval will extend from 4 feet below sandstone surface to the bottom of the borehole.

Construction/Performance Requirements - The sandstone extraction vent depth and construction requirements are illustrated on Drawing No. 5. The sandstone extraction vent will be fitted with a submersible ground-water pump, which will be installed within the well screen of the extraction vent as shown on Drawing No. 5. Ground-water extraction pump construction details are outlined in Subsection 4.2. The sandstone extraction vent will also be cased from ground surface to a depth of 2 feet below sandstone bedrock surface with a steel surface casing. The casing will serve to minimize any cross-contamination between the alluvium and sandstone. In addition, the sandstone extraction vent will be constructed to meet the following requirements:

• Quantity	(1) One.
• Orientation	Vertical.
• Piping Specifications	Well screen: 4-inch inner-diameter, 0.01 inch slot. Riser pipe: 4-inch inner-diameter.
• Borehole Diameter	8-inch (sandstone). 12-inch (alluvium).
• Surface Casing Specifications	8-inch diameter.
• Screened Interval	Top: 4 feet below sandstone bedrock surface. Bottom: 5 feet below claystone bedrock surface, and a minimum of 50 feet or a maximum of 90 feet bgs.
• Extraction Rate	Variable, typically 1 to 10 scfm/ft of screened interval.
• Operating Pressure	15-inch Hg negative pressure at the vent well head.

Wells will be developed in accordance with RFP SOP GW.02.

4.1.4 Sandstone Forced Air Injection Vent

Depth - The sandstone air injection vent will be constructed to a depth equal to that of the sandstone extraction vent. The screened interval will extend from 4 feet below sandstone bedrock surface to the bottom of the borehole.

Construction/Performance Requirements - The sandstone air injection vent depth and construction requirements are illustrated on Drawing No. 6. The sandstone air injection vent will be fitted with a submersible ground-water pump, which will be installed within the well screen of the air injection vent as shown on Drawing No. 6. Ground-water extraction pump construction details are outlined in Subsection 4.2. The sandstone air injection vent will also be cased from ground surface to a depth of 2 feet below sandstone bedrock surface with a steel surface casing. The casing will serve to minimize any cross-contamination between the alluvium and sandstone. In addition, the sandstone air injection vent will be constructed to meet the following requirements:

- Quantity — (1) One.
- Orientation — Vertical.
- Piping Specifications — Well screen: 4-inch inner-diameter, 0.01-inch slot.
Riser pipe: 4-inch inner-diameter.
- Borehole Diameter — 8-inch (sandstone).
8-inch (alluvium).
- Surface Casing Specifications — 8-inch diameter.
- Screened Interval — Top: 4 feet below sandstone bedrock surface.
Bottom: Total depth of sandstone extraction vent.

- Injection Rate — 10 - 50% of the extraction rate of the sandstone extraction vent.
- Operating Pressure — Maximum: 5 psi at air injection blower.

Wells will be developed in accordance with RFP SOP GW.02.

4.2 GROUND-WATER EXTRACTION PUMPS - GENERAL SPECIFICATIONS

Ground-water extraction pumps will be installed within the well screens at the bottom of the boreholes of the sandstone extraction vent and the sandstone forced air injection vent. Individual ground-water pumps will be sized to deliver ground water at a constant rate of 1 to 6 gpm from a depth of 90 feet bgs. The design extraction rate is 2.5 gpm. The electrical and ground-water conduits will extend from the submersible pump to the top of the borehole, and will exit through an air-tight seal in the vapor manifold. Configurations shown on Drawing Nos. 5 and 6 are typical only. Alternative layouts may be proposed (e.g., pitless adapters).

The performance specifications for the ground-water extraction pumps will be the following:

- Quantity — Two (2)
- Type — Stainless steel submersible
- Flow rate — 1 - 6 gpm (pump operating range)
- Diameter — 4-inch (maximum)
- Power requirements:
  - Horsepower — 1/3 HP
- Outlet connections — 3/4-inch (minimum)

In addition, ground-water extraction pumps will have the following requirements:

- Pumps will extract ground water from 4-inch diameter wells at a maximum depth of 90 ft.

- Pumps will be selected for continuous operation at any point of the performance curve for the specified pump speed.

- Each pump will include a run-time monitor for scheduling maintenance. The run-time monitor will be panel-mounted and provided by the subcontractor performing the services outlined in Section 6. Each pump should be equipped with an electrical connection designed for easy connection to their respective panel-mounted run-time monitor.

- Each pump will include a separate overload protector (to prevent motor overload if no fluid is being pumped).

- Each pump will be driven by a motor attached below the pump section.

- Submersible pumps and motors will be designed for continuous operation.

- All pumps, motors, and associated components will be compatible with the VOCs present in the water. Also, pumps will be designed to prevent any binding or breakage due to differential thermal expansion rates of the materials of construction.

- A panel-mounted hand/off/automatic switch shall be provided for each ground-water extraction pump by the subcontractor performing the services outlined in Section 6. The automatic mode shall invoke automatic control of the pump to maintain an approximately constant ground-water level in each well. Level control will be achieved by automatically setting a flow control valve on the ground-water effluent line to achieve a constant ground-water level. A low-level switch will be provided to override control and turn the pump off to prevent it from "running dry." Each pump should be equipped with an electrical connection designed for easy connection to their respective panel-mounted hand/off/automatic switch.

- The power cord will be of sufficient length to extend 75 feet beyond the top of the extraction vent casing. Connection of the power cord to the power source is described in Section 5.

- All electrical components will be suitable for use in a National Electric Code (NEC) Class 1, Division II environment.

- Each pump motor will be equipped with a separate overload device and thermal protector (to prevent motor overload if no fluid is being pumped) designed to meet NEC code for motor controllers.

Upon selection of the ground-water extraction pumps, the following information will be provided to EG&G-Rocky Flats, Inc. by the subcontractor providing the ground-water extraction pumps:

Pumps

- Rated Capacity
- Dynamic Head
- Static Head
- Total Discharge Head
- Flow Range
- Design Efficiency
- Manufacturer
- Model Number
- Performance Curve

Motors

- Speed
- Horsepower
- Volts/Phase/Frequency
- Diameter

All sizing calculations will be included in this submittal to EG&G.

Final sizing of ground-water extraction pumps will take place after the vents have been constructed. At that time, an accurate depth to water will be determined as well as the water yield from the sandstone vents.

4.3 PRESSURE MONITORING (PM) PROBES - GENERAL SPECIFICATIONS

The PM probes will measure subsurface negative pressures at various distances away from the extraction vents, which will be used to assess the radius of influence of each vent. The typical alluvial pressure monitoring probe will consist of 1- to 2-inch outer-diameter screened drive point pipe installed at a depth 2 feet above the total depth of its associated extraction vent. The screened portion of the drive point pipe is typically 1 foot in length, however, since the PM probes may also be employed as passive air inlets, the screened portion of the drive point pipe will be 3 feet in length to permit adequate air supply. In addition, the alluvial PM probes will be installed 4 feet above the total depth of the alluvial extraction vents since the alluvial extraction vents penetrate 2 feet into the sandstone bedrock surface. Specifically, it would not be desirable to have the alluvial PM probes installed 2 feet above the total depth of the alluvial extraction vents (i.e., at the alluvium/sandstone interface), since unanticipated perched ground water, if encountered, would affect their operation.

The typical sandstone pressure monitoring probe will consist of 1- to 2-inch outer-diameter well screen installed at a depth equal to the total depth of its associated extraction vent. The well screen will extend for the entire length of the screened interval of its associated extraction vent.

4.3.1 Alluvial PM Probes

Depth and Location - Drawing No. 1 shows the locations of the three PM probes for the alluvium. All alluvial PM probes will be constructed, installed, and completed to a depth of 2 feet above sandstone bedrock surface. As shown in Drawing No. 1, two probes will be placed on the southern side of T-4 at distances of 15 (APM2) and 20 (APM3) feet from the alluvial extraction vent. The remaining PM probe (APM1) will be placed on the northern side of T-4 at a distance of 5 feet from the alluvial extraction vent.

Construction/Performance Requirements - The alluvial PM probes depth and construction requirements are illustrated on Drawing No. 7. As shown on Drawing No. 7, the alluvial PM probes will be constructed to meet the following requirements:

•	Quantity	(3) Three.
•	Piping Specifications	Screened drive point pipe: 1- to 2-inch outer-diameter, 0.01-inch slot, 3-foot screened interval. Riser pipe: 1- to 2-inch outer-diameter.
•	*Borehole Diameter*	4-inch.

When installing the alluvial PM probes, the borehole will be advanced to a depth 5 feet above the desired completion depth (7 feet above the sandstone bedrock surface). The probe will then be driven into the soil the remaining 5 feet using the drill rig hydraulics or the split-spoon hammer. This will allow the drive point and screened section of the PM probe to be situated in undisturbed soil. If this technique is unsuccessful, the borehole will be advanced to its completion depth and the screened drive point pipe will be centered within the bottom of the borehole by a 5-foot-thick sandpack. The sandpack will be constructed of a sand with a sufficient size number so that sand will not enter the screened drive point pipe. A 1- to 2-inch outer-diameter riser pipe will be connected to the upper end of the screened drive point pipe and will be brought to a height 1 foot above ground surface. Directly above the undisturbed soil or sandpack (in the annulus around the riser pipe), a 1-foot layer of hydrated bentonite pellets will be emplaced, above which a cement/bentonite grout seal will be installed and brought to the ground surface. The top of the probe will be covered with an air-tight cap, which will have a port for attaching a pressure monitoring gauge.

4.3.2 Sandstone PM Probes

Depth and Location - Drawing No. 2 shows the locations of the two PM probes for the sandstone bedrock. The sandstone bedrock PM probes will be constructed, installed, and completed to a depth equal to the top of claystone bedrock surface, as determined by the installation of the sandstone bedrock extraction vent, or total depth of the bedrock extraction vent if 5 consecutive feet of claystone bedrock is not encountered during sandstone bedrock extraction vent construction. As shown on Drawing No. 2, one probe will be placed on the southern side of T-4 at a distance of 5 (SPM2) feet from the sandstone air injection vent, while the other probe will be placed on the northern side of T-4 at a distance of 5 (SPM1) feet from the sandstone extraction vent.

Construction/Performance Requirements - The sandstone PM probes depth and construction requirements are illustrated on Drawing No. 8. The sandstone PM probes will be cased from ground surface to a depth of 2 feet below sandstone bedrock surface with a steel casing. The casing will serve to minimize any cross-contamination between the alluvium and sandstone. As shown on Drawing No. 8, the sandstone PM probes will be constructed to meet the following requirements:

• Quantity	(2) Two.
• Piping Specifications	Well screen: 1-to 2-inch outer-diameter, 0.01-inch slot. Riser pipe: 1- to 2-inch outer-diameter.
• Borehole Diameter	4-inch (sandstone). 8-inch (alluvium).
• Surface Casing	4-inch diameter.
• Screened Interval	Top: 4 feet below sandstone bedrock surface. Bottom: Top of claystone bedrock surface or total depth of sandstone extraction vent.

When installing sandstone PM probes, the borehole will be advanced to its completion depth, and the well screen will be centered within the borehole by a sandpack which will extend to a height 1 foot above the top of the well screen. The sandpack will be constructed of a sand with a sufficient nominal grain size so that sand will not enter the well screen. A 1- to 2-inch outer-diameter riser pipe will be connected to the upper end of the well screen and will be brought to a height 1-foot above ground surface. Directly above the sandpack (in the annulus around the riser pipe), a 1-foot layer of hydrated bentonite pellets will be emplaced, above which a cement/bentonite grout seal will be installed and brought to the ground surface. The top of the probe will be covered with an air-tight cap, which will have a port for attaching a pressure monitoring gauge.

4.4 VAPOR MANIFOLDS - GENERAL SPECIFICATIONS

As shown on Drawing No. 9, vapor extraction vents and forced air injection vents will be connected to individual vapor headers by aboveground systems of 4- to 6-inch manifolds and 90-degree elbows (Drawing Nos. 3 and 4) or tees (Drawing Nos. 5 and 6). Manifolds from each extraction/injection vent will be equipped with a 4- to 6-inch-diameter butterfly valve which will be used to regulate the air flow in each vent. Manifolds from each extraction/injection vent will also be equipped with a changeable orifice plate to measure air flow rates. In addition, sampling ports for temperature, pressure, and sample collection will be provided as indicated on Drawing No. 9. Manifolds from the extraction vents will be sloped (1% slope) back towards the vent to provide drainage of condensate.

The vapor headers will be constructed for easy connection to the mobile vapor extraction pilot unit (described in Section 6). The mobile vapor extraction pilot unit will be equipped with a dilution air line and valve (located immediately upstream of the knockout drum/demister) for the vapor extraction header to prevent blower motor overload. The dilution air valve can be opened to allow ambient air into the blower during normal operation or in the event of the motor overheating, thereby relieving motor overload. In addition, the mobile vapor extraction pilot unit will be equipped with a bleed air line and valve (located downstream of blower B-3) for the air injection header. The bleed air valve can be opened during air injection periods to regulate the flow rate of air supplied.

4.5 PIPING REQUIREMENTS

All materials used for piping, pipe joining and seaming, and associated fittings (e.g., valves, caps, ports, etc.) described in Section 4 will be chemically resistant to and compatible with TCE, TCA, carbon tetrachloride, chloroform, PCE, and other VOCs. Piping materials will consist of polyvinyl chloride (PVC), chlorinated PVC (CPVC), high-density polyethylene (HDPE), steel, or polypropylene as decided by the subcontractor providing the services described in this section with EG&G-Rocky Flats, Inc. approval. Double-wall piping will be used for all groundwater and knockout drum effluent lines.

4.6 OPERATING TEMPERATURE RANGE (WINTERIZATION)

All non-buried piping and associated fittings outside of the equipment trailer will be winterized to prevent freezing of extracted moisture during the winter months. Winterization will consist of insulating jackets and heat tape (if necessary). Thermocouples will be employed to regulate heat tape elements. All thermocouples and heat tape elements will be protected from the expected environmental conditions (protection to -20 degrees fahrenheit [°F] minimum) encountered year round at the RFP.

4.7 USEFUL LIFE REQUIREMENTS

All materials and construction activities outlined in Section 4 will be designed and installed for a useful life of at least 5 years from date of acceptance.

4.8 DRILLING AND SAMPLING PROCEDURES

4.8.1 Drilling Procedures

Most of the drilling will be performed using a truck-mounted, hollow stem auger drilling rig. However, drilling for the installation of surface casing may be conducted using a solid stem, continuous flight, or bucket auger. Prior to drilling with solid stem or bucket auger, a (small diameter) pilot hole will be advanced to bedrock using a hollow stem auger to facilitate collection of undisturbed soil samples. Procedures associated with hollow stem auger drilling and sampling are described in RFP SOP No. GT.02. The borehole diameters specified in Subsections 4.1 through 4.3 are equivalent to the inner diameter of the hollow stem auger flights or outer diameter of the solid stem or bucket auger (for the installation of surface casing only). Drilling and sampling will be conducted with decontaminated equipment. Decontamination procedures are described in RFP SOP Nos. FO.03, FO.04, FO.06, and FO.12. Procedures for the handling of drilling fluids, cuttings, residual samples, and PPE are provided in RFP SOP Nos. FO.07, FO.08, and FO.09.

4.8.2 Sampling Procedures

Undisturbed soil samples will be collected continuously during hollow stem auger drilling. The samples will be collected using a "California" ring sampler. The entire length of the sampler will be lined with stainless steel or brass rings. Each ring will be 6 inches in length, 2.5 inches in outer diameter, and 2.4 inches in inner diameter. The sampler will be driven ahead of the auger to the desired depth with a standard 140-pound slide hammer falling freely from a height of 30 inches. The number of blows required to drive the sampler (12 or 18 inches, depending on the length of the sampler) will be counted and documented. Sampler refusal is defined as 100 blows with less than 6 inches of penetration. The sample will be brought to the surface and removed by opening the sampler along its length or by using an extruder. The sample rings will be screened for organic vapors using a portable photoionization detector (PID) or flame ionization detector (FID) such as an HNu or OVA (RFP SOP No. FO.15). The sample rings will also be scanned with a portable alpha field detector (RFP SOP No. FO.18). The sample will be visually inspected for soil type, staining, or other characteristics. Observations will be recorded in a field logbook and on soil boring logs. Soils will be described according to the unified soil classification code (RFP SOP No. GT.01). The ends of the metal rings will be covered with Teflon sheeting, capped with air-tight plastic caps, sealed with tape, labeled, and stored in an iced cooler.

Only selected soil samples will be analyzed for VOCs and radionuclides. For soil samples collected during the advancement of soil borings for extraction vents, the three samples that displayed the highest organic vapor readings will be analyzed for VOCs. If no organic vapors are detected during field screening, samples will be collected from 6 feet bgs (assumed total depth of disposal trench T-4), from the bottom of the borehole and from the midpoint of the boring. Procedures for containerizing, preserving, handling and shipping water and soil samples are presented in RFP SOP No. FO. 13.

For soil samples collected during the advancement of soil borings associated with the installation of PM probes, the sample displaying the highest organic vapor reading will be analyzed for VOCs. If no organic vapors are detected during field screening, the sample collected from the midpoint of the boring will be analyzed for VOCs.

Radiochemical analyses will be limited to samples collected from borings advanced for vent well construction only. The intention is to investigate the likelihood of recovering radionuclide-contaminated soil particles during pilot test operation. As PM probes will be used for air inlet or injection, there is minimal risk of mobilizing radioactive soil particles at the PM probes during operation of the system.

For each soil boring, the soil samples collected at 5, 10, and 15 feet will be composited, and one sample submitted for laboratory radionuclide analyses. The ring sampler will contain at least two rings per sample interval, therefore, it will be possible to submit one undisturbed ring for VOC analyses and use the second ring to create the composite sample for radionuclide analyses. The compositing procedure is described below.

Soils will be extruded from the appropriate sampling rings, placed on clean butcher or kraft paper, and divided so that no clumps remain. Each corner of the paper will be lifted alternatively, rolling the soil over on itself and towards the opposite corner. This procedure will continue until the soil has been rolled onto itself 20 times. The sample aliquot will be collected by removing the needed amount from at least five different areas of the mixed soil pile.

4.8.3 Analytical Procedures

Soil samples will be analyzed, as appropriate, for TCL VOCs and radionuclides including gross alpha and beta; strontium 89, 90; plutonium 239, 240; americium 241; and total uranium 233/234, 235, 238. Analytical procedures will conform to those described in General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G, 1990).

4.8.4 *Field Activities to Support Remedial Design at OU 2*

Figure 1-1 shows the locations of three of the five proposed boreholes. These locations are based on previous detections of Non-Aqueous Phase Liquid (NAPL), or liquid in Trench T-3 near Alluvial Pressure Monitor (APM) 25 Borehole (BH) 10191 and will be used for additional characterization east of SVE wells. One borehole will be located near BH 10191 (Approximately 5 feet east), the other boreholes will be located near APM-25 (within 5 feet) and in the eastern end of Trench T-3 (approximately 50 feet east of BH 24793). The fourth borehole will be located approximately five feet north of boring 25294. The fifth borehole will be located midway between borings 25294 and 25394. A geophysical survey was conducted prior to drilling to identify the presence of metal below the drilling locations. The geophysical method selected for this purpose used a Geonics EM-31 terrain conductivity meter operating in continuous recording mode over the survey area per RFETS ERM SOP GT.18, Surface Geophysical Surveys.

Table 1-1 summarizes the drilling program and analytical testing for site characterization of Trench T-3. Equipment rinsate samples will be collected prior to drilling and sampling each day when sampling is performed. Equipment rinsate samples will be collected in accordance with the Quality Assurance Project Plan (QAPP). Drilling and sampling of each soil boring will be performed in compliance with SOP GT.02, Drilling and Sampling Using Hollow Stem Auger Techniques. Boreholes will be drilled and sampled to 10 feet using 3.5-inch inside diameter (ID) hollow stem augers. The boreholes will be continuously sampled to total depth using a 2-foot split spoon sampler. Discrete samples will be collected for volatile organic analysis (VOA) in stainless-steel liners inside the split spoon. The two VOA samples exhibiting the highest Photoionization Detector (PID) readings will be selected for analysis. If no organic compounds are detected by the PID, VOA samples will be collected from the 5-foot and 10-foot intervals. One composite sample over a 2-foot interval will be collected for Total Organic Carbon (TOC) analysis from each borehole. Composite samples for radiological screening and SVOC will be collected from the 5-foot and 10-foot intervals. The prescribed compositing technique is described in SOP FO.13, Containerization, Preservation, Handling, and Shipping of Soil and Waste Samples. If the presence of NAPL is detected in e borehole, a bailer will be used to collect the liquid. The NAPL will be analyzed for VOCs and SVOCs. Table 1-1 identifies the samples to be collected and the analyses required. Sample numbers for the boreholes will be established by Rocky Flats Environmental Database System (RFEDS) for tracking and transfer of analytical data to EG&G. The field geologist will visually log the core from the borehole using the Unified Soil Classification System (USCS). Core recovered in the drilling operations will be boxed and stored in a designated EG&G storage facility. The core will be logged in detail according to SOP GT.1, Logging Alluvial and Bedrock Material. The borehole logs will then be transcribed into logger log format.

If liquids are encountered during drilling and removal is required, a peristatic pump (or equivalent) may be used to transfer the liquid to the appropriate storage container.

Following the drilling and sampling, the boreholes will be abandoned with a bentonite/ cement grout mixture from the total depth to the surface using a side discharge tremie pipe. The group mixture shall consist of 99% organic free bentonite grout with no polymer additives, mixed in a ratio of 5% bentonite to 95% cement by weight with approximately 8 gallons of water to every 100 pounds of bentonite/cement mix, as per SOP GT.5, Plugging and Abandonment of Boreholes. A mud balance will be used to assure grout density is not less than 9.9 pounds per gallon prior to use. A monument designating the borehole number, the project name and date will be placed at the surface 24 hours after the grout has cured.

Personnel involved in drilling and sampling will comply with the site specific Health and Safety Plan. Drilling and sampling will be performed by personnel in level B Personnel Protective Equipment (PPE). Personnel will consist of: a field geologist, a Health and Safety Specialist (HSS), and a technician to monitor the air supply, as well as the drill rig operator and helper.

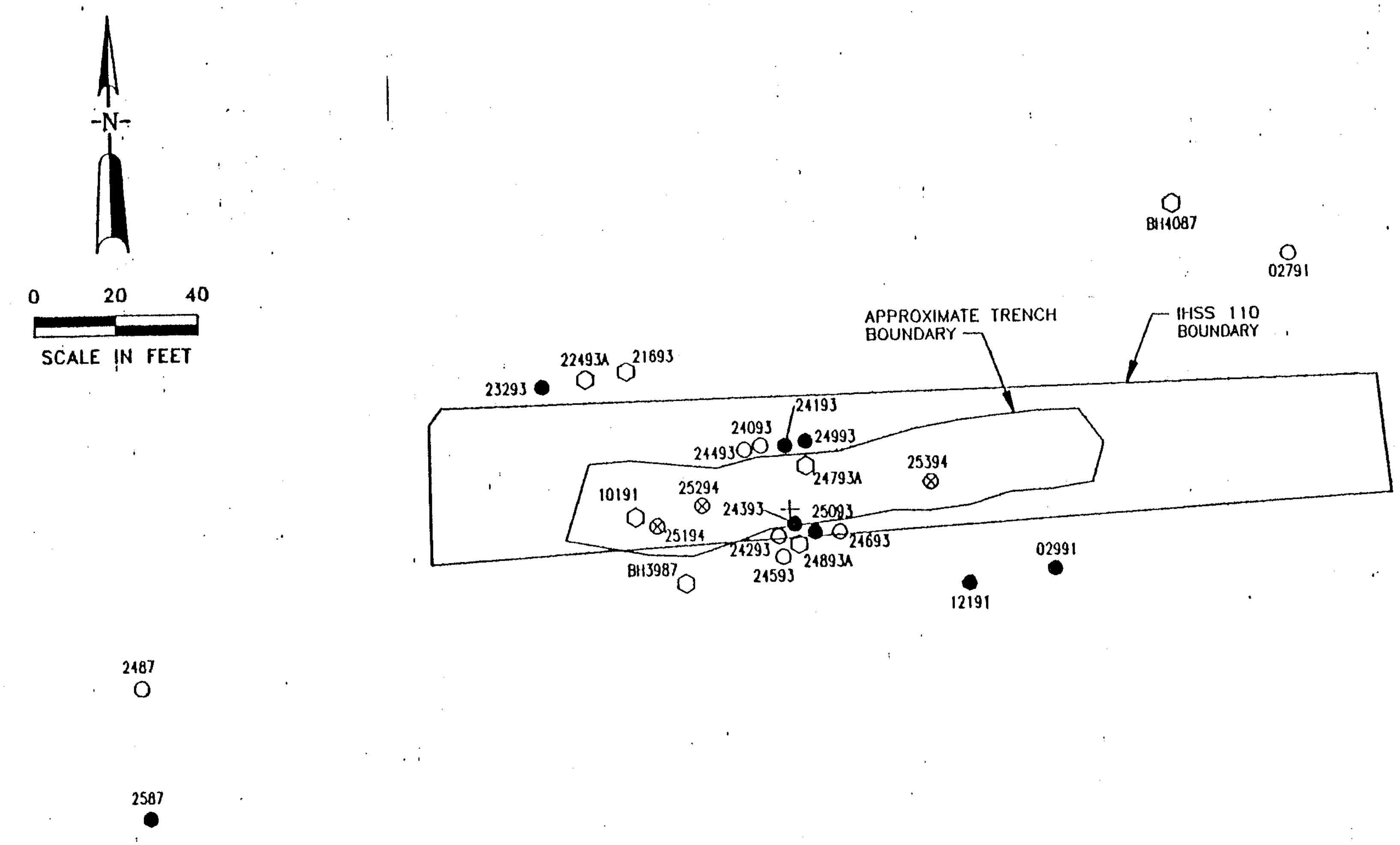
All soil and liquid waste generated by drilling activities will be containerized per SOP FO.08, Handling of Drilling Fluids and Cuttings, and SOP FO.10, Receiving, Labeling and Handling Environmental Materials Containers. PPE will be disposed of per SOP FO.06, Handling of Personal Protective Equipment.

The drill rig and downhole drilling and sampling equipment (augers, bits, hex rods, etc.) will be decontaminated at the main decontamination facility before mobilizing to the SVE field site and following completion of drilling activities, per SOP FO.03, General Equipment Decontamination, and SOP FO.04, Heavy Equipment Decontamination. The drill rig will also be inspected and approved by both the Subcontractor and RFETS safety personnel before it will be allowed to proceed to the drill site.

Table 1-1
Rocky Flats Environmental Technology Site
OU-2 SVE
DRILLING SUMMARY TABLE

Number of Borehole Locations	Projected Total Depth (feet)	Borehole Diameter (inches)	Samples per Borehole: Number of Samples (1)	Sample Type	Lab Method(s)	Depth
3	10	6.25	2	TPH	8015 (modified)*	Highest two PID or at mid-point and bottom of boring
				VOC	8240	Highest two PID or at mid-point and bottom of boring
				SVOC	8270**	Highest two PID or at mid-point and bottom of boring (2-foot composite)
			2	Rad Screen	Gross Alpha, Beta	Collected with the VOC's
			2	Rad Screen	Gross Alpha, Beta	Collected with SVOC's
			1-2	TPH	8015 (modified)*	Rinsate Sample (collected once per day)
				VOC	8240	Rinsate Sample (collected once per day)
				SVOC	8270**	Rinsate Sample (collected once per day)
			1	TOC	415.1	2-foot composite to be determined by the field geologist

Notes:
(1) Samples per borehole.
* - Analysis for gasoline and diesel (peak recognition).
** - Analysis for additional selective ion monitoring for suspect high molecular weight compound.
- Laboratory will be required to selectively monitor for ions of suspect high molecular weight oils.
- NAPL samples will be collected as encountered.



EXPLANATION

10191 ⬡ SOURCE BOREHOLE LOCATION

2487 ○ ALLUVIAL MONITORING WELL LOCATION

12191 ● BEDROCK MONITORING WELL LOCATION

22493A ⬡ ABANDONED MONITORING WELL LOCATION

110 INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION

25194 ⊗ PROPOSED BOREHOLE

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

OPERABLE UNIT 2
SUBSURFACE IM/IRA SITE 1

PROPOSED BORHOLE LOCATIONS

FIGURE 1.1

OCTOBER 1994

SVE-ART 1-40

SECTION 5
SITE PREPARATION

5.1 INTRODUCTION

Site preparations will be necessary to facilitate the installation and operation of the pilot SVE system. The following subsections discuss tasks to be performed such as preparation of site access, installation of a ground-water storage tank, supply of a portable power source, and connection of aboveground equipment.

It should be noted that the subcontractor providing the services described in this section will submit design drawings and design calculations to EG&G-Rocky Flats, Inc. for approval prior to purchasing any equipment and/or materials and prior to initiating any construction activities.

5.2 SITE ACCESS/PREPARATION

Prior to installation and operation of the pilot SVE system, proper site access will be made available. As shown on Figure 5-1, the gravel roadway to the northwest of T-4 will be used for site access.

A temporary site work area will be constructed by gravel covering an approximate 5,000-square-foot area located at the northwestern corner of T-4 (see Figure 5-1). The gravel cover will be approximately 6 inches thick (compacted). The aboveground storage tank for the extracted ground water (see Subsection 5.3) will be installed on the site work area. During SVE

Project Manager

Quality Assurance Program Manager

1) **Figure 5-1 Trench T-4 Area Layout** (11" x 17" figure)

operation, the system equipment trailer and the ground-water tank wagon (when necessary) will be located on the site work area. The gravel cover for the site work area will provide sufficient bearing strength to support the anticipated vehicular traffic and the ground-water storage tank.

To minimize disturbance to the surface soils in the East Trenches Area, the work site area will be leveled by the use of additional gravel to fill in localized low areas. Grading of the surface soils will not be performed. In addition, dust suppression techniques, such as wetting the surface soils, will be employed to satisfy the performance standards included in the Health and Safety Plan.

5.3 GROUND-WATER STORAGE AND TRANSPORTATION

Ground water will be recovered from the sandstone vapor extraction/air injection vents at a design rate of 5 gpm. Extracted ground water will be pumped to a 10,000-gallon or greater (air space capacity) enclosed modular, prefabricated or frac storage tank installed on the site work area. The storage tank will be designed not to exceed the bearing strength of the gravel cover and underlying alluvium. The storage tank will be properly supported to maintain tank integrity, provide structural support to tank bottom and side walls, and prevent differential settlement. Access to the top of the tank will be provided. The storage tank will be provided with secondary containment. The secondary containment used wil be either a double-walled tank with interstitial leak detection of a temporary containment structure surrounding the tank. Drip pads for spill control will be provided for storage tank and tank truck hose connections, and will be used during tank truck loading. The storage tank and all associated equipment will be constructed of materials chemically resistant to and compatible with TCE, PCE, carbon tetrachloride, chloroform, and TCA and other VOCs. The storage tank will be designed to maintain proper operation at all expected ambient conditions (described in Subsection 6.2.4). This includes heat tracing to prevent freezing and tie-downs to keep the storage tank in place during periods of high wind. In addition, the storage tank will include the following:

- inlet port (1)
- discharge port (1)
- access manway (1)
- atmospheric breather vent with attached GAC canister (1)
- level gauge (1)
- high level alarm with automatic ground-water pump shutoff (see Drawing No. 11 for required process control loop) (1)
- temperature gauge (1)

Transportation of ground water from the aboveground storage tank to the South Walnut Creek Water Treatment System will be provided by EG&G-Rocky Flats, Inc. A 5,000-gallon pump truck will be utilized for this purpose. The capacity of the pump truck is such that the pump truck will be able to empty the tank on a daily basis (i.e., transport a daily maximum of 7,200 gallons), allowing for an adequate turnaround time during unloading. At the South Walnut Creek Water Treatment System, the water will be transferred to the system's equalization tank. Details concerning the capacity of the South Walnut Creek Treatment System were presented in the IRAP.

5.4 PORTABLE POWER SOURCE

Because of the remote location of the East Trenches Area, a portable power source will be required. The equipment run off this power source will include all the equipment on the equipment trailer (see Section 6), ground-water extraction pumps, and any heating system required for the ground-water storage tank and the aboveground piping. The portable power source will meet the following specifications:

- Minimum Power Rating - 125 kilowatts (kW)
- Voltages - 110/230/460

- Phases - 1 and 3
- Maximum Voltage Drop - 25%
- Fuel - Diesel
- Max. Fuel Consumption Rate - 6 gal/hr
- Min. Fuel Capacity - 48 hrs.
- Cooling System - Radiator

In addition, the portable power source will be trailer-mounted to allow easy transport throughout the facility. The portable power source will be designed to withstand expected environmental conditions as described in Subsection 6.2.4. The location of the portable power source will be approved by EG&G.

These specifications are subject to change based on the equipment (blowers, ground-water pumps, analytical instruments, etc.) selected. The portable power source specifications and sizing calculations will be submitted to EG&G prior to purchase.

5.5 EQUIPMENT CONNECTIONS

Prior to system operation, all components of the pilot SVE system will be connected. This will include but will not be limited to the following:

- Connection of vapor extraction header to designated connection on equipment trailer.

- Connection of forced air injection header to designated connection on equipment trailer.

- Connection of ground-water extraction wells and knockdown drum water discharge stream to the ground-water storage tank.

- Connection of ground-water extraction wells, equipment trailer, and ground-water storage tank to the power source.

Following pilot system assembly, the completed pilot system will be checked to verify proper connection of all associated equipment.

Project Manager

Quality Assurance Program Manager

SECTION 6

MOBILE VAPOR EXTRACTION PILOT UNIT SPECIFICATIONS

6.1 INTRODUCTION

The mobile vapor extraction pilot unit is comprised of two blowers, vapor treatment system, and associated equipment. The purpose of this unit is to (1) induce a negative pressure to extract air out of the extraction vents, (2) treat the vapors and air prior to discharge, and (3) provide measurement of critical performance parameters. In addition, the air injection blower is considered part of the mobile vapor extraction pilot unit. The mobile vapor extraction pilot unit includes the following major components:

- Positive Displacement Blowers for Air Extraction and Injection
- Knockout Drum/Demister
- HEPA Filters
- Vapor-Phase GAC Units
- In-line Process Indicators for Pressure, Temperature, Flow Rate, Relative Humidity, and Radiation

The mobile vapor extraction pilot unit will be trailer-mounted to provide portability among proposed SVE test locations. It should be noted that the mobile vapor extraction pilot unit was designed for pilot testing SVE technology at all of the candidate OU2 test sites (i.e., IHSS Nos. 109, 110, 111.1, 112, and 113). A general site layout schematic is shown in Figure 6-1.

1) **FIGURE 6-1 Schematic Work Site Layout**

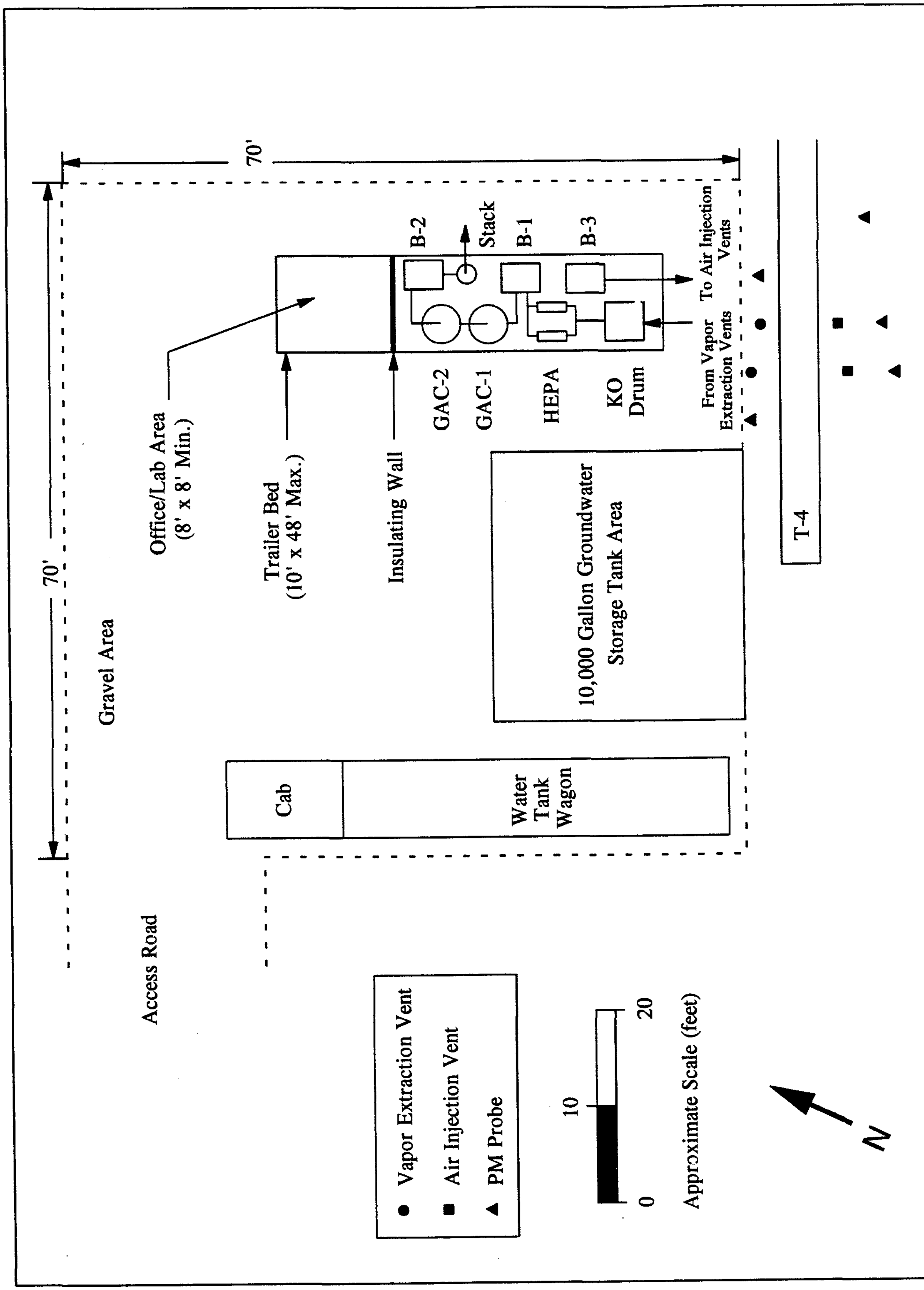


FIGURE 6-1: SCHEMATIC OF WORK SITE LAYOUT

The following subsections provide the design and performance specifications for the individual components of the mobile vapor extraction pilot unit. Also included is a discussion of the process monitoring and control instrumentation. It should be noted that, although specifications are given for individual equipment, all equipment will be supplied as a single operating unit. To supplement the information provided here, refer to the process and instrumentation diagrams (P&ID) provided (see Drawing Nos. 10 and 11 in Appendix A) .

It should be noted that the subcontractor providing the services described in this section will submit design drawings and design calculations to EG&G-Rocky Flats, Inc. for approval prior to purchasing any equipment and/or materials and prior to initiating any construction activities.

6.2 GENERAL SPECIFICATIONS

This subsection details the general specifications that apply to all of the mobile vapor extraction pilot unit equipment discussed in this section. The system and all equipment components will be designed, constructed, and installed to comply with all applicable Occupational Safety and Health Administration (OSHA) requirements as well as state or local building codes or electrical codes.

6.2.1 Chemical Resistance

The mobile vapor extraction pilot unit, by its purpose, will be designed to withstand chemical attack from the compounds expected to be encountered during operations. These compounds are expected to include carbon tetrachloride, PCE, TCE, chloroform, 1,1,1-trichloroethane, and other VOCs. Although these compounds are not expected in a pure form, it is remotely possible that percent levels ($>$10,000 parts per millon [ppm]) could be encountered in the extracted vapors. All equipment on the mobile vapor extraction pilot unit will be resistant to chemical attack from the expected compounds at percent levels.

6.2.2 Electrical Requirements

A portable power source, described in Section 5, will be used to supply power to all of the equipment associated with the mobile pilot unit. The power requirements for the equipment specified in this section will have an impact on the power supply to be used. Therefore, the power requirements of all the equipment from the mobile vapor extraction pilot unit will be supplied to EG&G-Rocky Flats, Inc. by the subcontractor supplying the mobile vapor extraction pilot unit. Included for each piece of equipment will be:

- Voltage
- Amperage
- Phase (e.g., 1 or 3 phase)
- Special requirements - This would include any other information that may effect the requirements of the power source.

All electrical components and wiring will be suitable for use in a NEC Class I, Division II environment.

6.2.3 Noise Levels

Noise level specifications are not presented for individual components of the mobile vapor extraction pilot unit, rather, a specification for the unit as a whole will be followed. The unit is expected to be operated in relatively remote locations, without nearby residences. However, the unit will be operated such that the unit will comply with all applicable OSHA requirements (29 CFR 1910.95) for noise levels (i.e., maintain employee noise exposures at or below an 8-hour time-weighted average sound level of 85 decibels at a distance of 3 feet from the mobile vapor extraction pilot unit).

6.2.4 Ambient Operating Conditions

The mobile vapor extraction pilot unit is expected to be utilized for several pilot tests at the RFP. To ensure proper operation year-round, all equipment will be properly fitted to withstand all environmental conditions that could be reasonably expected in the Denver, Colorado area. This includes the expected low temperatures during the winter months (< 0 °F) and the high temperatures during the summer months (> 100 °F). Winds in excess of 100 mph can be expected at the site. All equipment shall be rated for operation at 6,000 feet above mean sea level (MSL).

6.2.5 Deviations from Performance Specifications

If there is a deviation from the performance specifications, the subcontractor supplying the mobile vapor extraction pilot unit will submit the following information to EG&G-Rocky Flats, Inc. for approval.

- Nature of deviation
- Reason for deviation
- Impact of deviation on system performance

6.2.6 Design Information

Design information for the mobile vapor extraction pilot unit will be submitted by the subcontractor to EG&G-Rocky Flats, Inc. for approval. The design submittals will include:

- Manufacturer's shop drawings for each major process component, including equipment specifications and materials of construction.

- Detailed record drawings of the mobile vapor extraction pilot unit after construction is completed.

- Design calculations.

- Operating and maintenance manuals for major components and equipment.
- Operating and maintenance manual for the full system.

Documentation of the mobile vapor extraction pilot unit system operations (SO) testing will accompany the design package. This documentation will detail the SO testing procedures utilized as well as the results of the SO testing. Manufacturer-specified SO testing procedures will be followed when available. Any deviations from required performance specifications will be noted. Refer to Subsection 6.2.5 for more information regarding deviations.

It should be noted that SO testing will be performed by the subcontractor supplying the mobile vapor extraction pilot unit while an EG&G-Rocky Flats, Inc. representative is present.

6.3 BLOWER PERFORMANCE SPECIFICATIONS

6.3.1 Introduction

As shown on Drawing No. 11, the mobile vapor extraction pilot unit will utilize two blowers (B-1 & B-2) to provide the necessary pressure differential during operations. A dual-blower configuration was specified for the following reasons:

- The vapor treatment system is operated under negative pressure. This reduces the chance of a release of untreated vapors. The blowers will be sized such that a vacuum across the blowers is maintained at all operating vent pressures.
- Higher carbon capacity can be expected. This is due to the decrease in relative humidity of the air due to the heat input from blower B-1.
- Power requirements are reduced. Because neither blower operates at the high end of the negative pressure range (15 to 17 inches Hg), they can operate more efficiently.

- A heat exchanger is not required. If the vapor treatment system is downstream of the blower (configuration presented in the Subsurface IM/IRA Plan), a heat exchanger and the associated water cooling system is required to reduce the airstream temperature to acceptable levels for GAC treatment.

The following subsections present the performance specifications for each blower.

6.3.2 <u>Blower B-1</u>

The performance specifications for Blower B-1 shall be the following:

- Type - Positive Displacement, Gas-Tight
- Inlet flow rate - 600 actual ft^3/min (acfm) @ 25 inches Hg absolute (abs).
- Pressure - 25 inches Hg abs.
- Max. Blower Speed - 80% of maximum revolutions per minute (RPM)
- Temperature Rise Across Blower - 30-50 °F
- Interval Between Oil Changes - 750 hrs. (minimum)
- Power Requirements:
  - Horsepower - 10 brake horsepower (BHP)
  - Voltage - 220/440 volts (V), 3 phase, 60 hertz (Hz)
- Inlet/Outlet Connections - 4-inch (minimum)
- Motor Type - Explosion Proof

- Motor Starter Type - Combination starter (i.e., includes circuit breaker)

- Drive Mechanism - Belt

- Accessories:

  - Vacuum Relief Valve

  - High Temperature Shutdown Switch (setpoint as specified by the blower manufacturer, see Drawing No. 11)

  - Inlet/Discharge Silencers (see Subsection 6.2.3)

  - Control panel-mounted operational time controller (capable of automatic, timed operation) and 3 position hand/off/automatic power switch

  - Control panel-mounted run-time monitor (used for maintenance scheduling)

- All electrical components will comply with operation in a National Electrical Code (NEC) Class I, Division II location (i.e., approved for work in an area in which explosive conditions exist frequently or in routine operations resulting from potentially flammable gases or vapors in the air).

Any deviations from the above specifications will be noted. Refer to Subsection 6.2.5 for more information regarding deviations from performance specifications. In addition to the above, the following information will be provided to EG&G-Rocky Flats, Inc. by the subcontractor supplying the mobile vapor extraction pilot unit at the time of equipment selection and prior to equipment purchase:

- Manufacturer
- Model number
- Blower performance curve
- Dimensions and weight
- Noise level (without muffler)
- Materials of construction

6.3.3 Blower B-2

The performance specifications for Blower B-2 shall be the following:

- Type - Positive Displacement, Gas-Tight
- Inlet flow rate - 500 acfm @ 18 inches Hg abs.[1]
- Pressure - 18 inches Hg abs.
- Max. Blower Speed - 80% of maximum RPM
- Max. Temperature Rise Across Blower - 150 °F
- Interval Between Oil Changes - 750 hrs. (minimum)
- Power Requirements:
  - Horsepower - 20 BHP
  - Voltage - 220/440V, 3 phase, 60 Hz
- Inlet/Outlet Connections - 4-inch (minimum)
- Motor Type - Explosion Proof
- Motor Starter Type - Combination Starter
- Drive Mechanism - Belt
- Accessories:
  - Vacuum Relief Valve

---

[1] This flow rate will be dependent on the pressure drop of the GAC units utilized and the operating temperature. The flow rate will be matched with blower B-1 to ensure that the GAC units are always operating at negative pressure.

- High Temperature Shutdown Switch (setpoint as specified by the blower manufacturer, see Drawing No. 11)

- Inlet/Discharge Silencers (see Subsection 6.2.3)

- Control panel-mounted operational time controller (capable of automatic, timed operation) and 3 position hand/off/automatic power switch

- Control panel-mounted run-time monitor (used for maintenance scheduling)

• All electrical components will comply with operation in a NEC Class I, Division II environment

Any deviations from the above specifications will be noted. Refer to Subsection 6.2.5 for more information regarding deviations from performance specifications. In addition to the above, the following information will be provided to EG&G-Rocky Flats, Inc. by the subcontractor supplying the mobile vapor extraction pilot unit at the time of equipment selection and prior to equipment purchase:

• Manufacturer
• Model number
• Blower performance curve
• Dimensions and weight
• Noise level (without muffler)
• Materials of construction

6.3.4 Blower B-3

The performance specifications for Blower B-3 (air injection blower) shall be the following:

• Type - Regenerative or Positive Displacement

• Outlet flow rate - 200 acfm @ 5 psi pressure

- Maximum Operating Pressure - 5 psi
- Max. Blower Speed - 80% of maximum RPM
- Temperature Rise Across Blower - 30-70 °F
- Interval Between Oil Changes - 750 hrs. (minimum)
- Power Requirements:
  - Horsepower - 7.5 BHP
  - Voltage - 220/440V, 3 phase, 60 Hz
- Inlet/Outlet Connections - 4-inch (minimum)
- Motor Type - Explosion Proof
- Motor Starter Type - Combination Starter
- Drive Mechanism - Belt
- Accessories:
  - Pressure Relief Valve
  - High Temperature Shutdown Switch (setpoint as specified by the blower manufacturer, see Drawing No. 11)
  - Inlet/Discharge Silencers (see Subsection 6.2.3)
  - Control panel-mounted operational time controller (capable of automatic, timed operation) and 3 position hand/off/automatic power switch
  - Control panel-mounted run-time monitor (used for maintenance scheduling)
- All electrical components will comply with operation in a NEC Class I, Division II environment

Any deviations from the above specifications will be noted. Refer to Subsection 6.2.5 for more information regarding deviations from performance specifications. In addition to the above, the following information will be provided to EG&G-Rocky Flats, Inc. by the subcontractor supplying the mobile vapor extraction pilot unit at the time of equipment selection and prior to equipment purchase:

- Manufacturer
- Model number
- Blower performance curve
- Dimensions and weight
- Noise level (without muffler)
- Materials of construction

6.4 KNOCKOUT DRUM/DEMISTER

6.4.1 General

As shown in Drawing No. 11, extracted vapor is first passed through a knockout drum/demister to remove entrained condensate that may be present. The demister is packed with a mesh that provides a large surface area so that entrained liquid will coalesce into droplets that gravity separate from the vapor. Water is accumulated in the knockout drum/demister until a certain high liquid level setpoint is reached. Then the water is automatically pumped (Pump P-1) from the drum to the ground-water storage tank until the water level falls to the designated low liquid level setpoint, at which point pump P-1 is shut off. A high-high-liquid level alarm will also be included (see Subsection 6.8.2).

It is anticipated that the liquid(s) collecting in the demister will be inspected for the presence of DNAPL using an electronic interface probe or equivalent method. If DNAPL is detected, the demister will be retrofitted with a phase separator.

6.4.2 Design Specifications

The knockout drum/demister will meet the following performance specifications:

- Maximum air flow rate - 650 scfm
- Minimum capacity - 100 gallons
- Minimum removal efficiency - 99%
- Operating Vacuum - 15 inches Hg
- Applicable Codes - ASME Boiler and Pressure Vessel Code, Section VIII, Division I
- Max. pressure drop - 8 inches H_2O
- Pump P-1:
  - Type - Positive Displacement
  - Maximum pump rate - 5 gpm
  - Controlling mechanism - Automatic; batch discharge of accumulated water
  - Run-time monitor - Control panel-mounted (used for maintenance scheduling)

It should be noted that pump P-1 must be sized to overcome the hydraulic head resulting from the knockout drum discharge line junction with the ground-water extraction line.

In addition to the above, the following information will be provided for the knockout drum/demister and for the pump to EG&G-Rocky Flats, Inc. by the subcontractor supplying the mobile vapor extraction pilot unit at the time of equipment selection and prior to equipment purchase:

- Identification of all components
- Construction material

- Dimensions
- Location and depth of level switches
- Sizes of piping and valves

6.5 HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS

The vapor exiting the demister is filtered by a HEPA filtration unit. HEPA filters contain fabric filtration media that is capable of removing particulates as small as 0.3 microns. HEPA filtration prevents fouling of downstream process equipment and ensures operation within particulate emission standards. As shown in Drawing No. 11, two HEPA filters are in a parallel configuration. The parallel configuration allows filters to be changed without shutting down the system. In addition, if the pressure drop becomes significant due to higher than expected levels of particulates, both filters can be operated to reduce the pressure drop.

The performance of the HEPA filters must meet Federal Standard 209b for removing particulates. This standard specifies that particles as small as 0.3 microns will be removed at an efficiency of 99.7% or greater. The pressure drop (clean) will not exceed 10 inches H_2O (at 300 scfm).

6.6 VAPOR TREATMENT SYSTEM

As shown on Drawing No. 11, the vapor treatment system for the mobile vapor extraction pilot unit will consist of two, vapor-phase GAC units connected in a series configuration. The following performance specifications will be met for each GAC unit:

- GAC unit capacity - 1,800 pounds (minimum)
- Contaminant removal efficiency - 99% of PCE, TCE, and CCl_4
- Operating vacuum - 12 inches Hg

- Applicable Codes - ASME Boiler and Pressure Vessel Code, Section VIII, Division I.
- Connections - 4-inch (minimum)
- Construction materials - Compatible with VOCs in air stream and weather resistant.

The GAC units will allow for easy placement on the system trailer by a fork lift. The daily carbon consumption rate will depend on the volumetric air flow rate and VOC concentrations encountered during pilot system sustained operations. Initial estimates of GAC usage indicate that if the VOC concentration for each contaminant is 10 parts per million volume/volume (ppmv), 30 pounds of GAC will be used per day. At that rate, one GAC unit would need to be replaced every 60 days. Although the carbon efficiency increases as the inlet VOC concentrations increase, a conservative estimation indicates that if the inlet VOC concentration of each contaminant is 100 ppmv, one carbon unit would need to be replaced every 6 days (300 pounds of GAC would be used each day). During the initial stages of the pilot study, hydrocarbon analysis of the extracted vapor stream will yield a better indication of the actual GAC consumption rate.

Following vapor-phase GAC treatment, the vapor stream will pass through blower B-2 and be vented to the atmosphere through an emission stack. The stack will be designed to withstand wind and weather loads and must also be designed for easy transportation from test site to test site. The performance specifications for the stack are as follows:

- Orientation - Vertical
- Height - 10 ft. above top of trailer
- Operating temperature - 250-300 °F
- Diameter - 6-inch (maximum)
- Materials of Construction - Weather resistant
- Wind Loading - 100 mph (minimum)

6.7 EQUIPMENT TRAILER

The equipment trailer selected to house the vapor extraction pilot unit will be designed for use on public roads. It will conform to all applicable Department of Transportation (DOT) requirements. The trailer will also be designed with any needed weather protection to withstand the climate extremes at the test site (i.e., temperature, wind). Trailer tie down points, which are capable of withstanding 100 miles per hour (mph) winds, must be provided. Trailer design will include garage-style doors which will allow for fork-lift access for carbon unit changeout. The trailer will be equipped with adequate ventilation, and will include climate controls (heating and/or cooling) to maintain temperatures within acceptable limits as required by the equipment specified in this section. To reduce vibrations, all blowers will be mounted on vibration-dampening pads.

In addition, the trailer is to include an insulated, climate controlled office area (minimum 8 feet in length by 8 feet in width) with a separate entrance way.

6.8 MONITORING/INSTRUMENTATION

Details of the monitoring equipment and the control loops are shown on Drawing No. 11. Most of the monitoring equipment will provide real-time, in-line measurement of system operating parameters. Other monitoring procedures, such as real-time hydrocarbon and radiation monitoring, are explained in more detail. As shown, the system will be equipped with various automatic shutdowns to terminate operations if equipment is operating outside of acceptable limits. In this event, a central alarm beacon, located on the top of the trailer, will activate, thus alerting operators outside of the trailer. In almost all cases, the control loops will cut power to the blowers (including the air injection blower), thus ceasing operations. Ground-water extraction will continue unless the level in the ground-water storage tank becomes too high (in which case the power will be cut to the knockout drum discharge pump [pump P-1]). Any subsequent liquid accumulation in the knockout drum will continue until the high liquid level alarm is triggered, at which point all system blowers will be automatically shutdown.

The following subsections provide more detailed information concerning the monitoring devices, and the automatic control loops that will be part of the vapor extraction unit. In general, the instrumentation indicators for readout will be located at the control panel. All instrumentation devices will have sufficient weather proofing to withstand temperature extremes. All instrumentation devices must also have a visible, dated calibration sticker.

6.8.1 Radiation Monitoring System Specifications

The pilot unit will include the exhaust gas sampling system shown on Drawing No. 11. The purpose of the system is to provide field verification that radionuclide-contaminated particulates are not present in the exhaust gas discharged from the process.

The sampling system will have the capability of continuously withdrawing a portion of the exhaust gas at a point downstream of blower B-2, and filtering it with a HEPA filter to remove any particulates that may be present. A pump will be used to meter the flow of exhaust gas from the stack to one of two sample tubes. Each of the sample tubes will contain a removable HEPA filter. As Drawing No. 10 indicates, the sample tubes will be configured in parallel with manual hand valves that allow the flow of gas to be directed to either of the sample tubes. The gas sampling system will include piping that returns the filtered gas sample to the exhaust stack and will be supplied with a differential pressure gauge to monitor the pressure drop across either HEPA filter. All sample piping connections will be sealed to prevent leakage under the pilot unit operating conditions. Process exhaust operating parameters are estimated as follows: 150 - 250°F, 300 - 600 scfm, and 1 - 5 inches of water.

The sample tubes will be designed so that the HEPA filter may be easily removed from and re-inserted into the sample tube without disassembly of the tube. Sample tube design will include a sufficiently adequate seal so that while in operation, there will be no leakage around the HEPA filter, i.e., the entire gas sample will pass through the HEPA filter.

In operation the HEPA filters will be removed from the sample tube and measured in the field for alpha radiation with a benchtop alpha detection unit. The alpha meter is part of the exhaust gas sampling and radiation measurement system, and will therefore be provided as part of the vapor extraction pilot unit. The alpha counting instrument will be microprocessor controlled, and have the capability to measure the total alpha activity of the following isotopes: plutonium-239, 240; americium-241; and uranium 234, 235, and 238. Detailed pilot test procedures for use of the exhaust gas sampling and radiation measurement system specified herein is presented in Subsection 7.4.6.

Performance specifications for each of the primary elements of the exhaust gas sampling and alpha radiation measurement system are as follows:

Piping:

- Sample Metering Pump - 0 - 50 liters per minute
  Manually controlled, variable duty
- HEPA filter pore size - 0.1 microns (nominal)
- Pressure gauge - 0 - 5 inches water (differential)

Alpha Detector and Signal Conditioning Electronics:

- Range - 0 - 500 disintegrations per minute (dpm).
- Digital display - 0 - 500 dpm.
- Detection efficiency - 20 percent of alpha present (nominal).

6.8.2 Knockout Drum/Demister Condensate Level Indicators

Entrained water from the extracted vapor stream will be collected in the knockout drum/demister. The collected water will be pumped from the knockout drum to the groundwater holding tank. The knockout drum will be equipped with a level sensor and indicator for readout. When a designated high level is reached within the drum, the high liquid level sensor will activate the water pump. Similarly, when a designated low level is reached, the low liquid level sensor will automatically shut off the water pump. Additionally, when a designated high liquid level is reached within the drum, the high liquid level sensor will activate an operational warning alarm (indicating system shutdown due to high liquid level in the knockout drum), activate the mobile vapor extraction pilot unit alarm beacon, and automatically shut down the system blowers. The knockout drum water pump will continue to operate after triggering the high liquid level alarm. However, once the system blowers are shut down, the system will have to be manually restarted.

6.8.3 Volumetric Air Flow Rate

The system volumetric air flow rate will be measured using automatic flow indicator gauges. There will be two such indicators as part of the system. One will be located on the dilution air line prior to the knockout drum, and one will be located prior to the venting of the air stream to the atmosphere. Also, flow totalizers will measure the cumulative air flow through the dilution air line, and exiting the stack. These totalizers will provide (by determining the flow balance) the volume of air extracted from the extraction vents.

6.8.4 System Pressure

Pressure will be measured throughout the system by in-line pressure indicator gauges. There will be eight pressure indicators in the system, placed to monitor operating pressures and pressure drops throughout the system. The first will be located on the dilution air line prior to the knockout drum. The second will be located on the vapor extraction manifold inlet prior to the dilution air line. The third will be located after the knockout drum and prior to the HEPA filters. The fourth will be located after the HEPA filters and prior to the vacuum relief valve. The fifth will be located after blower B-1 and prior to the GAC-1 treatment unit. The sixth will be located after GAC-1 and prior to GAC-2. The seventh will be located after the GAC-2 treatment unit and prior to the vacuum relief valve. The eighth will be located prior to venting the air stream to the atmosphere through the system stack.

6.8.5 Extracted Air Stream Temperature

Temperature of the extracted air stream will be measured throughout the system by in-line temperature indicators. There will be four temperature indicator gauges in the system. The first will be located on the dilution air line prior to the knockout drum. The second will be located on the vapor extraction manifold inlet prior to the dilution air line. The third will be located after blower B-1 and prior to treatment unit GAC-1. The fourth will be located at the stack.

In addition to these gauges, separate high temperature shutoff controls will be included on blowers B-1 and B-2, which upon activation will automatically shut down all system blowers (including the forced air injection blower), signal an operational warning alarm (indicating system shutdown due to high blower temperature at the respective blower), and activate the mobile vapor extraction pilot unit alarm beacon. Blower B-3 (the forced air injection blower) will also include a high temperature shutoff control, however, this control will only shut down blower B-3 while leaving blowers B-1 and B-2 in operation. In addition, the high temperature shutoff control for blower B-3 will signal an operational warning alarm (indicating system shutdown due to high blower temperature), and activate the mobile vapor extraction pilot unit alarm beacon if the temperature of the blower exceeds its setpoint. Blower shutdown setpoints will be established at temperatures specified by the blower manufacturers. Once the blowers are shut down, they must be manually restarted.

6.8.6 Relative Humidity

The system will measure relative humidity of the air stream using in-line relative humidity indicator gauges. There will be three relative humidity indicator gauges for the system. The first will be located on the dilution air line prior to the knockout drum. The second will be located on the vapor extraction manifold prior to the dilution air line. The third will be located after blower B-1 and prior to treatment unit GAC-1. The indicators located upstream of blower B-1 will facilitate accurate air flow rate measurements by correcting the flow rate measured to account for moisture content (i.e., calculation of dry cubic feet of air per minute). The third indicator will monitor the moisture entering the GAC units, and will allow the operators to optimize system operating conditions to maximize carbon efficiency (i.e., minimize moisture content entering the carbon treatment units).

6.8.7 Hydrocarbon Sampling Ports

There will be three sample ports on the trailer system to allow for manually taking grab air samples from the air flow for hydrocarbon analysis. One port will be located between blower B-1 and treatment unit GAC-1. A second port will be located between units GAC-1 and GAC-2. The third port will be located between unit GAC-2 and the vacuum relief valve. The sampling ports, in conjunction with on-site analysis (discussed in Section 7), will provide near real-time (2- to 4-hour turnaround) measurement of hydrocarbon concentrations.

6.9 CONTROL PANEL

An instrument control panel will be installed in the office/laboratory portion of the trailer. The panel will display all pilot process variables, equipment operational status, equipment run-time monitors, and system alarms. This "centralized" display is intended to streamline process data collection during pilot and post-pilot operation. The control panel will also serve as the power distribution center for the pilot unit. A single power feed from the generator will be split into several switched sources at the control panel.

The subcontractor will submit control panel layout and wiring diagrams to EG&G. Purchase of control panel components and panel fabrication is contingent upon EG&G approval of the diagrams submitted. All process and control panel instrumentation and power wiring will conform to NEC and National Equipment Manufacturer's Association standards.

6.9.1 Process Instrumentation

Drawing No. 11 presents the specific process variables, operational signals, and system alarms that are to be indicated on the control panel. The control panel will be installed in the office/laboratory portion of the process trailer such that the center of the instrument display is at approximately eye level to an operator in a standing position.

Electrical process measurement signals are to be conditioned and displayed in engineering units by microprocessor-based digital indicators. All instrument signal and power wiring will be installed neatly in the process trailer and within the control panel. Termination boards will be installed in the control panel and used to connect all field wiring to the panel-mounted indicators. Switched, multi-channel indicators will be used to display "like" variable measurements (e.g., temperatures). A selector switch will be mounted on the panel adjacent to each multi-channel indicator. Each multi-channel indicator used will have a minimum of three spare channels reserved for future use. It should be noted that run-time monitors and hand/off/automatic switches will also be mounted on the control panel for each groundwater extraction pump.

Each process pressure signal will be transmitted to a dedicated panel-mounted gauge by tubing that is compatible with the process conditions at the point of measurement. All tubing will be installed neatly in the process trailer and within the control panel.

The subcontractor will assign tag names to each process parameter, operational signal, and system alarm. The tag names will conform to standard Instrumentation Society of America nomenclature. A name tag, legibly bearing the process signal tag name, will be securely affixed to the field sensors, termination points, and panel-mounted indicators. Spare channels of multi-channel indicators will be tagged "Spare."

The panel area dedicated to process instrumentation display shall be sized to include approximately 30 percent "spare" space to accommodate future additions of panel-mounted instrumentation.

6.9.2 Power

As noted above, the electric power supply line from the generator will be split into several switched sources at the control panel. The sources will include at a minimum of five 110 VAC and two 220 VAC switched outlets. The panel will include a dedicated circuit breaker for each switched power supply and will be electrically grounded. Power conditioning equipment will be installed on the main feed to the panel. The panel will be configured such that the switched power outlets will be accessible from the front of the panel. Power cords will be used to provide power from the panel to the electrical components of the vapor and ground-water extraction systems. All power lines will be tagged with voltage and amperage specifications.

Project Manager

Quality Assurance Program Manager

SECTION 7
PILOT TEST OPERATIONS

7.1 INTRODUCTION

This section presents the guidelines and procedures that will be followed during the pilot test operations. This section is intended to give a general overview of the procedures. It is possible that the identified procedures will be modified to better reflect field conditions encountered. In the event of a deviation from these procedures, proper documentation in the field logbook will be made to justify and explain the deviations.

The pilot test operations will be divided into the following four phases: system operations (SO) testing, pilot testing, sustained operations, and IM/IRA operations. SO testing will ensure that the SVE system is operating as designed prior to conducting the pilot tests. The pilot tests will determine the range of operating conditions for various system configurations. This information will determine the optimal operating configuration yielding the maximum contaminant removal to be used during the sustained operations period. A total of nine pilot tests will be performed over a period of approximately four to six weeks.

Following the pilot testing period, sustained operations may be conducted. The decision to conduct sustained operations will be based on the ability of the system to successfully remove VOCs from the subsurface. Preliminary guidance for determining success is a VOC recovery rate of at least 1 pound per 24 hours of actual operation (i.e., 24-hour operating period). This guidance is completely arbitrary and may be modified as data are collected during pilot testing. The selection of 1 pound of VOCs per 24-hour operating period is discussed in Section 7.4.

Sustained operations may continue beyond the minimum 6-week period until the pilot unit is required at another site, or until breakthrough of VOCs occurs in the lead GAC unit. In the latter case, the lead GAC unit will be replaced, and the pilot unit will remain on standby for use at the next pilot test site. Data collected during the sustained operations period will be evaluated to determine the benefit of returning to the East Trenches Area pilot test site for IM/IRA operation (final project phase). Criteria that will be used to evaluate the SVE data are discussed in Section 8 of this Test Plan. Final decisions regarding sustained and IM/IRA operations will be made by the EG&G Project Manager.

7.2 SYSTEM OPERATIONS TESTING

Following connection of the aboveground equipment, SO testing procedures will be initiated to verify the proper installation and operation of the system, to gather operating information, and to establish the optimal operating parameters for sustained operation of the system. All information gathered during the pilot operations will be maintained in the field logbook.

The first step of the SO testing will involve inspection of all components of the system. This inspection will include, but not be limited to, the following equipment:

- Piping - visually examine for cracks, loose connections, and possible leaks.
- Valves - verify proper operation.
- Blowers - follow manufacturer's inspection procedures (i.e., check oil, belts, etc.).
- Knockdown Drum/Demister - follow manufacturer's inspection procedures.
- GAC Units - follow manufacturer's inspection procedures.
- HEPA Filters - inspect filters for debris or blockage.
- Alarms/Automatic Shutdowns - check for proper operation at design settings, follow manufacturer's inspection procedures.

- Monitoring Equipment/Instrumentation - follow manufacturer's inspection and calibration procedures.

An SO test checklist will be prepared by the subcontractor performing the pilot test operations. The checklist will be supplied to EG&G-Rocky Flats, Inc. for approval prior to SO testing. The approved checklist will be completed during conduct of the SO test, and submitted to EG&G-Rocky Flats, Inc. As previously mentioned, an EG&G representative must be present during the SO test. The operations subcontractor will also provide all equipment/instrumentation calibration records to EG&G-Rocky Flats, Inc. along with the completed SO checklist. In addition, the subcontractor will provide supplemental sections to the mobile vapor extraction pilot unit operations and maintenance manual to detail the operations (gas sampling, etc.) not covered by the manual. Prior to use of the equipment during pilot testing, an Operational Readiness Review (ORR) will be prepared by EG&G.

Upon completion of the initial inspection, the blowers will be "bumped" to verify the proper air flow direction. Bumping a blower involves turning the blower on briefly, with only dilution air supplied (i.e., the dilution air valve is fully opened, while all system vents remain closed), and checking the air flow direction.

7.3 PILOT TEST RUN OVERVIEWS

Once the system has passed the inspection, pilot tests will be performed. These tests will be of relatively short duration and will be designed to determine the range of operating conditions that can be achieved by various system configurations, and the optimal operating conditions for sustained operations of the SVE system. In addition, the pilot tests will be used to estimate the capacity and changeout requirements of the activated carbon units. The time required to conduct the pilot tests is expected to be approximately 4 to 6 weeks. The project schedule (see Section 9) provides for a duration of 3 months as a contingency for "setbacks."

The following subsections outline the pilot tests to be performed following system SO testing. There will be a total of nine pilot tests, and each test will include one to three discrete runs. The nine pilot tests are listed below:

- Pilot Test No. 1 - Initial Vapor Treatment System Performance.
- Pilot Test No. 2 - Alluvium System Performance.
- Pilot Test No. 3 - Sandstone System Performance.
- Pilot Test No. 4 - Concurrent Ground-Water Extraction and Sandstone System Performance.
- Pilot Test No. 5 - Concurrent Alluvium and Sandstone System Performance.
- Pilot Test No. 6 - Alluvium Passive Air Inlet Performance.
- Pilot Test No. 7 - Sandstone Passive Air Inlet Performance.
- Pilot Test No. 8 - Alluvium Forced Air Inlet Performance.
- Pilot Test No. 9 - Sandstone Forced Air Inlet Performance.

The various system configurations and minimum operating times to be employed for the pilot tests are summarized in Table 7-1. Actual running times will be based on the time required to achieve steady state vacuum pressure distribution in the subsurface as defined for each pilot test in Sections 7.3.2 through 7.3.9. The pilot tests will be run until the steady state condition is achieved. If this condition is established before the minimum operating time has expired, the test will be continued for the minimum operating time.

The measurements made during these tests will be used to evaluate air permeability of individual strata and to estimate the time required to reach steady state operation in each stratum. The type and schedule for measurements is presented in Table 7-2. It should be noted that the schedule of measurements is aggressive, and may require adjustment in the field based on available manpower.

Pilot Test No.	Purpose	Configuration	Minimum Operating Time	Text Reference
1	Evaluate performance of vapor treatment system to ensure that no VOC breakthrough occurs; pressure check system; check instrumentation.	AV1 open; SV1 vent closed; supply ambient air as necessary	4 hr.	7.3.1
2	Evaluate alluvium system performance.	AV1 open; SV1 vent closed; supply ambient air as necessary.	48 hr.	7.3.2
3	Evaluate sandstone system performance w/o groundwater extraction.	AV1 closed; SV1 open; supply ambient air as necessary.	48 hr.	7.3.3
4	Evaluate sandstone system performance with groundwater extraction	AV1 closed; SV1 open; supply ambient air as necessary.	16 hr.	7.3.4
5	Evaluate interaction between alluvium and sandstone systems.	AV1 open; SV1 open; supply ambient air as necessary; groundwater extraction based on results of Test 4.	16 hr.	7.3.5
6-7[a]	Evaluate passive air inlet.	Use configurations from Tests 2, and 3 or 4; opening the passive air inlets.	16 hr. each	7.3.6-7
8-9[a]	Evaluate air injection	Use configurations from Tests 2, and 3 or 4; supply air injection.	16 hr. each	7.3.8-9

[a] Pilot Test Nos. 6-9 will be configured based on the information gathered during previous tests.

1) **TABLE 7-1 Overview of Pilot Tests**

7.3.1 Pilot Test No. 1 - Initial Vapor Treatment System Performance

Description - Pilot Test No. 1 will evaluate the initial performance of the vapor treatment system following startup to ensure that contaminants are not discharged to the atmosphere and that safe operating conditions exist. In addition, Pilot Test No. 1 will provide a pressure check for the system under operating conditions and will verify proper operation of all vapor extraction unit equipment and instrumentation. Measurements to be taken during Pilot Test No. 1 are outlined in Table 7-2. Should initial stack OVA measurements read 10 relative response units above background, an air sample from the system stack will be immediately taken for laboratory analysis. A field gas chromatograph (GC) will be used to perform the analysis, thus providing real-time (2- to 4-hour turnaround) VOC measurement capability. The air sampling procedures to be followed are further discussed in Subsection 7.5.6. Further pilot tests will be suspended pending GC analysis of the air sample and subsequent system reevaluation. If the vapor treatment system performance is determined to be adequate, subsequent pilot tests will be performed.

Configuration - For Pilot Test No. 1, the alluvial extraction vent (AV1) will be fully opened and the sandstone extraction vent (SV1) will be closed. Pilot Test No. 1 will be performed at an AV1 vent operating pressure of 100 inches of water, as measured at AV1 itself. Dilution air will be supplied to the system blowers as necessary. Pilot Test No. 1 will be approximately 4 hours in duration.

7.3.2 Pilot Test No. 2 - Alluvium System Performance

Description - Pilot Test No. 2 will evaluate the performance of the alluvium vapor extraction vent (AV1) and will estimate the alluvium's air permeability. Pilot Test No. 2 results will be used to establish the following:

	Measurement/Frequency						
	P	Q	T	RH	Rad(2)	OVA	HC(3)
	1/(4-hour)	1/(4-hour)	1/(4-hour)	1/(4-hour)	1/(2-hour)	1/(4-hour)	1/(4-hour)
Location							
AV1	X	X				X	X
Dilution Air Line	X	X	X	X			
Vapor Manifold	X		X	X			
B-1 Out	X		X	X		X	X
GAC-1 Out	X					X	X
GAC-2 Out	X					X	X
Stack	X	X	X		X	X	

NOTES:

(1)- The pilot testing schedule may require adjustment in the field based on available manpower resources.

(2) - Sampling of exhaust gas for subsequent alpha radiation measurement is continuous. The "Rad" measurement frequency interval indicated corresponds to benchtop measurement of the sample filter media for alpha activity.

(3) - GC samples will be collected and analyzed over the 4-hour period (i.e., not simultaneously).

P - Pressure
Q - Flow rate
T - Temperature
RH - Relative humidity (moisture content)
Rad - Radiation
OVA - Field organic vapor analyzer
HC - Hydrocarbon sample (GC measurement)

2) **TABLE 7-2 Test No. 1 Schedule of Measurements**

- AV1 air flow rates at varying operating pressures.
- Contaminant removal rates at AV1 with varying operating pressures.
- Radius of influences of AV1 at varying operating pressures.
- Maximum radius of influence of AV1.
- Air permeability of the alluvium.
- Time required to reach steady-state in the alluvium.

Pilot Test No. 2 will consist of three separate runs, with each discrete run being performed at a different vent operating pressure. An identical series of measurements will be taken during each run of Pilot Test No. 2 as outlined in Table 7-3. Optimal AV1 operating configuration will be determined as the operating pressure resulting in the maximum contaminant removal rate.

Configuration - For all three runs of Pilot Test No. 2, AV1 will be opened and SV1 will be closed. Dilution air will be supplied to the system blowers as necessary. Individual runs of Pilot Test No. 2 will be conducted until steady-state operation is achieved (minimum of 16 hours in duration). Steady-state operation will be defined as being attained when the last three subsurface pressure measurements from PM probe APM3 (the PM probe farthest from AV1) are within 5 percent of each other.

7.3.3 Pilot Test No. 3 - Sandstone System Performance

Description - Pilot Test No. 3 will evaluate the performance of the sandstone vapor extraction vent (SV1) without the benefit of ground-water extraction, and will estimate the vadose sandstone's air permeability. However, should the ground-water table rise 30 inches or more within SV1 during system operations, ground-water extraction will be initiated and continued at a rate such that the depth to ground water within SV1 returns to and remains at its original level. If necessary, ground-water will be extracted concurrently from SV1 and the sandstone air injection vent (SI1). Pilot Test No. 3 results will be used to establish the following:

	Measurement/Frequency						
	P	Q	T	RH	Rad(3)	OVA	HC(4)
	1/(4-hour)	1/(4-hour)	1/(4-hour)	1/(4-hour)	1/(2-hour)	1/(4-hour)	1/(4-hour)
<u>Location</u>							
AV1	X	X				X	X
APM1(2)	X						
APM2(2)	X						
APM3(2)	X						
AI1(2)	X						
Dilution Air Line	X	X	X	X			
Vapor Manifold	X		X	X			
B-1 Out	X		X	X		X	X
GAC-1 Out	X					X	X
GAC-2 Out	X					X	X
Stack	X	X	X		X	X	

The following pressures will be used during Pilot Test No. 2:

Run No.	AV1 Vent Pressure (in. H2O)	Duration (Hours)
1	60	16
2	100	16
3	140	16

Pilot Test Nos. 6 & 8 will consist of single 16 hour runs, during which AV1 will be operated at its optimal operating pressure as determined by the results of Pilot Test No. 2.

NOTES: (1)- The pilot testing schedule may require adjustment in the field based on available manpower resources.
(2) - Pressure will be measured at 1 to 10 minute intervals during Pilot Test No. 2 to determine air permeability.
(3) - Sampling of exhaust gas for subsequent alpha radiation measurement is continuous. The "Rad" measurement frequency interval indicated corresponds to benchtop measurement of the sample filter media for alpha activity.
(4) - GC samples will be collected and analyzed over each 4-hour period (i.e., not simultaneously).
P - Pressure
Q - Flow rate
T - Temperature
RH - Relative humidity (moisture content)
Rad - Radiation
OVA - Field organic vapor analyzer
HC - Hydrocarbon sample (GC measurement)

3) TABLE 7-3 Test Nos. 2, 6 & 8 Schedule of Measurements

- SV1 air flow rates at varying operating pressures.
- Contaminant removal rates at SV1 with varying operating pressures.
- Radius of influences of SV1 at varying operating pressures.
- Maximum radius of influence of SV1.
- Air permeability of the vadose sandstone.
- Time required to reach steady-state in the vadose sandstone.

Pilot Test No. 3 will consist of three separate runs, with each individual run being performed at a different vent operating pressure. An identical series of measurements will be taken during each run of Pilot Test No. 3 as outlined in Table 7-4. The optimal operating configuration will be determined as the vent pressure resulting in the maximum contaminant removal rate.

Configuration - For all three runs of Pilot Test No. 3, SV1 will be opened and AV1 will be closed. Ground-water will not be extracted during Pilot No. 3, unless the ground-water table rises 30 inches or more within SV1 during system operations. Dilution air will be supplied to the system blowers as necessary. Individual runs of Pilot Test No. 3 will be conducted until steady-state operation is achieved (minimum of 16 hours in duration). Steady-state operation will be defined as being attained when the last three subsurface pressure measurements from PM probe SPM2 (the PM probe farthest from SV1) are within 5 percent of each other.

7.3.4 Pilot Test No. 4 - Concurrent Ground-Water Extraction and Sandstone System Performance

Description - Pilot Test No. 4 will evaluate the performance of the sandstone vapor extraction vent (SV1) with the benefit of ground-water extraction, and will evaluate the contaminant removal contribution from the dewatered sandstone. Ground water extraction will be initiated concurrently in SV1 and SI1 prior to system start-up at a rate of 2.0 gallons per minute (gpm)

	Measurement/Frequency							
	P	Q	T	RH	GW	Rad(3)	OVA	HC(4)
	1/(4-hour)	1/(4-hour)	1/(4-hour)	1/(4-hour)	1/(4-hour)	1/(2-hour)	1/(4-hour)	1/(4-hour)
Location								
SV1	X	X			X		X	X
SPM1(2)	X							
SPM2(2)	X							
SI1(2)	X				X			
Dilution Air Line	X	X	X	X				
Vapor Manifold	X		X	X				
B-1 Out	X		X	X			X	X
GAC-1 Out	X						X	X
GAC-2 Out	X						X	X
Stack	X	X	X			X	X	

The following pressures will be used during Pilot Tests Nos. 3 & 4:

Run No.	SV1 Vent Pressure (in. H2O)	Duration (Hours)
1	100	16
2	140	16
3	180	16

Pilot Tests Nos. 7 & 9 will consist of single 16 hour runs, during which SV1 will be operated at its optimal operating pressure as determined by the results of Pilot Test Nos. 3 & 4.

NOTES: (1)- The pilot testing schedule may require adjustment in the field based on available manpower resources.
(2) - Pressure will be measured at 1 to 10 minute intervals during Pilot Test No. 3 to determine air permeability.
(3) - Sampling of exhaust gas for subsequent alpha radiation measurement is continuous. The "Rad" measurement frequency interval indicated corresponds to benchtop measurement of the sample filter media for alpha activity.
(4) - GC samples will be collected and analyzed over each 4-hour period (i.e., not simultaneously).
P - Pressure
Q - Flow rate
T - Temperature
RH - Relative humidity (moisture content)
GW - Groundwater level
Rad - Radiation
OVA - Field organic vapor analyzer
HC - Hydrocarbon sample (GC measurement)

4) **TABLE 7-4 Tests Nos. 3, 4, 7, & 9 Schedule of Measurements**

from each well. Water levels in SV1, SI1 and PM probe SPM1 will be measured on an hourly basis. It is important to note that the actual pumping rate will depend on the amount of water the formation can yield. It is expected that 2.0 gpm from each well will result in a drawdown of over 10 feet in the pumping wells. If after 24 hours the drawdown in the pumping wells is less than 10 feet, the pumping rate may be increased at the discretion of the EG&G project manager.

Once the appropriate pumping rate is determined, the well will be pumped for 24 hours. If after 24 hours the water level has not stabilized, pumping will continue until the water level stabilizes. Stabilization is defined as less than a 0.1 foot change in water level in SPM1 (the PM probe nearest to SV1) over a 1-hour period. Once the water level has stabilized, the vacuum pumps will be turned on and ground water extraction will continue.

Pilot Test No. 4 will be performed in an analogous manner to Pilot Test No. 3. Specifically, Pilot Test No. 4 will consist of three separate runs performed at the same vent operating pressures as the three runs of Pilot Test No. 3 (see Table 7-4). The measurements to be taken during each run of Pilot Test No. 4 are identical to the measurements taken for the individual runs during Pilot Test No. 3 (see Table 7-4). Optimal SV1 operating configuration will be determined as the operating pressure resulting in the maximum contaminant removal rate. Ground-water extraction will be considered beneficial should it increase contaminant removal rates when compared with Pilot Test No. 3 results.

Three ground-water samples for laboratory analysis will be collected during Pilot Test No. 4. The first sample will be collected after ground-water has been pumped for a 12-hour period. The second sample will be collected following attainment of steady-state ground-water level conditions within PM probe SPM1. The third sample of collected at the end of Pilot Test No. 4. VOC, metal, and radionuclide analytes for ground-water analysis are summarized in Table 7-5, 7-6, and 7-7, respectively.

Table 7-5

Target Compound List Volatile Organic Compounds and Aqueous Phase Quantitation Limits

	Analyte	CAS Number	Aqueous Phase RQL ($\mu g/\ell$)[a,b]	Aqueous Phase PQL ($\mu g/\ell$)[c]
1.	Chloromethane	74-87-3	10	
2.	Bromomethane	75-83-9	10	
3.	Vinyl Chloride	75-01-4	10	
4.	Chloromethane	75-00-3	10	
5.	Methylene Chloride	75-09-2	5	
6.	Acetone	67-64-1	10	
7.	Carbon Disulfide	75-15-0	5	
8.	1,1-Dichloroethene	75-35-4	5	
9.	1,1-Dichloroethane	75-34-3	5	1
10.	1,2-Dichloroethene (total)	540-59-0	5	1
11.	Chloroform	67-66-3	5	1
12.	1,2-Dichloroethane	107-06-2	5	
13.	2-Butanone	78-93-3	10	
14.	1,1,1-Trichloroethane	71-55-6	5	
15.	Carbon Tetrachloride	56-23-5	5	
16.	Vinyl Acetate	108-05-4	10	
17.	Bromodichloromethane	75-27-4	5	
18.	1,1,2,2-Tetrachloroethane	79-34-5	5	
19.	1,2-Dichloropropane	78-87-5	5	
20.	trans-1,3-Dichloropropene	10061-02-6	5	
			5	
21.	Trichloroethene	79-01-6	5	
22.	Dibromochloromethane	124-48-1	5	
23.	1,1,2-Trichloroethane	79-00-5	5	
24.	Benzene	71-43-2	5	
25.	cis-1,3-Dichloropropene	10061-01-5	4	
26.	Bromoform	75-25-2	5	
27.	2-Hexanone	591-78-6	10	
28.	4-Methyl-2-pentanone	108-10-1	10	
29.	Tetrachloroethene	127-18-4	5	1
30.	Toluene	108-88-3	5	
31.	Chlorobenzene	108-90-7	5	
32.	Ethyl Benzene	100-41-4	5	
33.	Styrene	100-42-5	5	
34.	Total Xylenes	1330-20-7	5	

[a] Micrograms per liter.
[b] EPA Contract Laboratory Program (CLP) Required Quantitation Limit (RQL)
[c] EPA Method 502.2 Practical Quantitation Limit (PQL)

Source: General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Revision 1.1, EG&G-Rocky

Table 7-6

Metal Analytes and Aqueous Phase Detection Limits

Analyte	Aqueous Phase Detection Limit ($\mu g/\ell$[a])
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5,000
Celsium	1,000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Lithium	100
Magnesium	5,000
Manganese	15
Mercury	0.2
Molybdenum	100
Nickel	40
Potassium	5,000
Selenium	5
Silver	10
Sodium	5,000
Strontium	200
Thallium	10
Tin	200
Vanadium	50
Zinc	20

[a] Micrograms per liter.

Source: General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Revision 1.1, EG&G-Rocky Flats, Inc., September 1990.

Table 7-7

Radionuclides and Minimum Detectable Activities

Analyte	MDA	
	Water (pCi/ℓ[a])	Soil (pCi/g[b])
Gross Alpha	2	4
Gross Beta	4	10
Strontium 89,90	1	1
Plutonium 239,240	0.01	0.03
Americium 241	0.01	0.02
Tritium	400	400
Total Uranium 233/234, 235, 238	0.6	0.3

[a] Picocuries per liter.
[b] Picocuries per gram.

Source: General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Revision 1.1, EG&G-Rocky Flats, Inc., September 1990.

Configuration - For all three runs of Pilot Test No. 4, SV1 will be opened and AV1 will be closed. Ground-water will be extracted throughout the duration of Pilot Test No. 4 from both SV1 and SI1 at a rate such that the depth to ground-water within SV1 remains constant during vapor extraction system operation. Dilution air will be supplied to the system blowers as necessary. Individual runs of Pilot Test No. 4 will be conducted for a minimum of 16 hours following attainment of steady-state ground water levels. Criteria for termination of Pilot Test No. 4 based on attainment of steady-state pressure distribution conditions are discussed in Section 7.3.3.

7.3.5 Pilot Test No. 5 - Concurrent Alluvium and Sandstone System Performance

Description - Pilot Test No. 5 will evaluate the interaction between AV1 and SV1 when operated simultaneously and the resulting overall system performance. Pilot Test No. 5 will consist of a single run, during which AV1 will be operated at its optimal operating pressure (at the vent pressure resulting in greatest contaminant removal rate) as determined during Pilot Test No. 2. SV1 will also be operated at the optimal operating pressure as determined during Pilot Tests Nos. 3 and 4. Ground-water will be extracted from both SI1 and SV1 if it was determined to be either necessary during Pilot Test No. 3 or beneficial during Pilot Test No. 4. Measurements to be taken during Pilot Test No. 5 are outlined in Table 7-8.

Configuration - For Pilot Test No. 5, both AV1 and SV1 will be opened. Ground water may be extracted based on the results of Pilot Tests Nos. 3 and 4. Dilution air will be supplied to the system blowers as necessary. Pilot Test No. 5 will begin upon attainment of steady-state water level conditions (if applicable) as defined in Section 7.3.4. Pilot Test No. 5 will be conducted until steady-state pressure distribution conditions are achieved (minimum of 16 hours in duration) as defined in Sections 7.3.2 and 7.3.3.

7.3.6 Pilot Test No. 6 - Alluvium Passive Air Inlet Performance

	Measurement/Frequency							
	P	Q	T	RH	GW	Rad(2)	OVA	HC(3)
	1/(4-hour)	1/(4-hour)	1/(4-hour)	1/(4-hour)	1/(4-hour)	1/(2-hour)	1/(4-hour)	1/(4-hour)
Location								
AV1	X	X					X	X
APM1	X							
APM2	X							
APM3	X							
AI1	X							
SV1	X	X			X		X	X
SPM1	X							
SPM2	X							
SI1	X				X			
Dilution Air Line	X	X	X	X				
Vapor Manifold	X		X	X				
B-1 Out	X		X	X			X	X
GAC-1 Out	X						X	X
GAC-2 Out	X						X	X
Stack	X	X	X			X	X	

NOTES:

(1)- The pilot testing schedule may require adjustment in the field based on available manpower resources.
(2) - Sampling of exhaust gas for subsequent alpha radiation measurement is continuous. The "Rad" measurement frequency interval indicated corresponds to benchtop measurement of the sample filter media for alpha activity.
(3) - GC samples will be collected and analyzed over each 4-hour period (i.e., not simultaneously).
P - Pressure
Q - Flow rate
T - Temperature
RH - Relative humidity (moisture content)
GW - Groundwater level
Rad - Radiation
OVA - Field organic vapor analyzer
HC - Hydrocarbon sample (GC measurement)

8) **TABLE 7-8 Test No. 5 - Schedule of Measurements**

Description - Pilot Test No. 6 will evaluate the use of the alluvium air injection vent (AI1) as a passive air inlet and its influence on alluvium system performance. Pilot Test No. 6 will consist of a single run, during which AV1 will be operated at its optimal operating pressure as determined during Pilot Test No. 2. Measurements to be taken during Pilot Test No. 6 are identical to the measurements collected for Pilot Test No. 2 (see Table 7-3). The use of AI1 as a passive air inlet will be considered beneficial should it increase contaminant removal rates when compared with Pilot Test No. 2 results. If the use of AI1 as a passive air inlet is determined to be advantageous, other alluvial PM probes may be employed as passive air inlets during the sustained operations period.

Configuration - For Pilot Test No. 6, AV1 will be opened and SV1 will be closed. AI1 will be opened to the atmosphere. Dilution air will be supplied to the system blowers as necessary. Pilot Test No. 6 will be run for a minimum of 16 hours. If steady-state pressure distribution conditions are not achieved after 16 hours, the test will continue until steady-state conditions, as defined in Section 7.3.2., are achieved.

7.3.7 Pilot Test No. 7 - Sandstone Passive Air Inlet Performance

Description - Pilot Test No. 7 will evaluate the use of the sandstone air injection vent (SI1) as a passive air inlet and its influence on sandstone system performance. Pilot Test No. 7 will consist of a single run, during which SV1 will be operated at its optimal operating pressure as determined during Pilot Tests Nos. 3 and 4. Ground water will be extracted from SV1 and SI1 if it was determined to be either necessary during Pilot Test No. 3 or beneficial during Pilot No. 4. Measurements to be taken during Pilot Test No. 7 are identical to the measurements collected for Pilot Test Nos. 3 and 4 (see Table 7-4). The use of SI1 as a passive air inlet will be considered beneficial should it increase contaminant removal rates when compared with Pilot Tests Nos. 3 and 4 results. If the use of SI1 as a passive air inlet is determined to be advantageous, other sandstone PM probes may be employed as passive air inlets during the sustained operations period.

Configuration - For Pilot Test No. 7, SV1 will be opened and AV1 will be closed. SI1 will be opened to the atmosphere. Ground water will or will not be extracted based on the results of Pilot Tests Nos. 3 and 4. Dilution air will be supplied to the system blowers as necessary. Pilot Test No. 7 will be run for a minimum of 16 hours following attainment of steady-state ground water level conditions as defined in Section 7.3.4. If after 16 hours steady-state pressure distribution conditions have not been achieved, as defined in Section 7.3.2, the test will continue until steady-state conditions are established.

7.3.8 Pilot Test No. 8 - Alluvium Forced Air Inlet Performance

Description - Pilot Test No. 8 will evaluate the use of the alluvium air injection vent (AI1) as a forced air inlet and its influence on alluvium system performance. Pilot Test No. 8 will consist of a single run, during which AV1 will be operated at its optimal operating pressure as determined during Pilot Test No. 2. Measurements to be taken during Pilot Test No. 8 are identical to the measurements collected for Pilot Test No. 2 (see Table 7-3). The use of AI1 as a forced air inlet will be considered beneficial should it increase contaminant removal rates when compared with Pilot Test No. 2 results.

Configuration - For Pilot Test No. 8, AV1 will be opened, SV1 will be closed, and AI1 will be supplied a constant flow of air from blower B-3. The constant AI1 air flow rate will be equivalent to the maximum AI1 air injection rate (not to be greater than 50 percent of AV1's extracted air rate) which maintains APM2's subsurface pressure at or below atmospheric pressure. To determine AI1's air flow rate, AI1 will be supplied air from blower B-3 at varying flow rates (in the range of 10 to 50 percent of AV1's extracted air rate) upon commencing Pilot Test No. 8, but prior to initiating measurements. Subsurface pressure measurements will then be taken at APM2 to monitor that injected air is being withdrawn at AV1. If the subsurface pressure at APM2 is greater than atmospheric pressure, the air injection rate will be decreased until the subsurface pressure at APM2 is equal to or less than atmospheric pressure. Once a suitable AI1 air flow rate has been determined, Pilot Test No. 8 measurements will begin.

Dilution air will be supplied to the system blowers as necessary. Pilot Test No. 8 will be run until steady-state pressure distribution conditions are achieved (16 hour minimum duration) as defined in Section 7.3.2.

7.3.9 Pilot Test No. 9 - Sandstone Forced Air Inlet Performance

Description - Pilot Test No. 9 will evaluate the use of the sandstone air injection vent (SI1) as a forced air inlet and its influence on sandstone system performance. Pilot Test No. 9 will consist of a single run, during which SV1 will be operated at its optimal operating pressure as determined during Pilot Tests Nos. 3 and 4. Ground-water will be extracted from SV1 and SI1 if it was determined to be either necessary during Pilot Test No. 3 or beneficial during Pilot Test No. 4. Measurements to be taken during Pilot Test No. 9 are identical to the measurements collected for Pilot Tests No. 3 and 4 (see Table 7-4). The use of SI1 as a forced air inlet will be considered beneficial should it increase contaminant removal rates when compared with Pilot Tests No. 3 and 4 results.

Configuration - For Pilot Test No. 9, SV1 will be opened, AV1 will be closed, and SI1 will be supplied a constant flow of air from blower B-3. The constant SI1 air flow rate will be equivalent to the maximum SI1 air injection rate (not to be greater than 50 percent of SV1's extracted air rate) which maintains SPM2's subsurface pressure at or below atmospheric pressure. To determine SI1's air flow rate, SI1 will be supplied air from blower B-3 at varying flow rates (in the range of 10 to 50 percent of SV1's extracted air rate) upon commencing Pilot Test No. 9, but prior to initiating measurements. Subsurface pressure measurements will then be taken at SPM2 to monitor that injected air is being withdrawn at SV1. If the subsurface pressure at SPM2 is greater than atmospheric pressure, the air injection rate will be decreased until the subsurface pressure at SPM2 is equal to or less than atmospheric pressure. Once a suitable SI1 air flow rate has been determined, Pilot Test No. 9 measurements will begin. Dilution air will be supplied to the system blowers as necessary. Pilot Test No. 9 will be begin once steady-state ground water level conditions have been achieved, as defined in Section 7.3.4.

Pilot Test No. 9 will be run until steady-state pressure distribution conditions have been established (16 hour minimum duration) as defined in Section 7.3.3.

7.4 SUSTAINED OPERATIONS

After completion of the system operation and pilot tests, sustained operations of the mobile vapor extraction pilot unit may be conducted for the next 6 weeks or until the pilot unit is required at the next test site. Sustained operations will be performed if the pilot tests indicate that VOCs are being recovered at a rate which equals or exceeds 1 pound of VOCs per 24-hour operating period. This criteria is completely arbitrary and may be modified based on pilot testing data. A recovery rate of 1 pound of VOCs per 24-hour operating period corresponds to approximately 10 ppmv of VOCs (total) in a 300 scfm SVE process stream (see Appendix E). An initial VOC concentration of 10 ppmv is sufficient to observe contaminant concentration decreases with time, and to evaluate the cost-effectiveness of the SVE pilot unit. Final decisions regarding sustained operation will be made by the DOE in consultation with EPA and the Colorado Department of Health.

During the sustained operations period, the system will operate continuously. The system will be configured to match the optimal conditions for both the alluvium and sandstone vents (both vents will operate during sustained operations) as determined during the pilot tests. The information gathered during the sustained operations period will be used to support the evaluation of the technology in the FS and to assess the benefit of IM/IRA operation. Of particular importance will be the contaminant removal rate versus time, and the radius of influence of the vents. These critical parameters may provide valuable cost and long-term performance information.

The data to be collected during the sustained operations is presented in Table 7-9. The collection of this data will utilize the same methods as identified for the pilot tests.

	Measurement/Frequency							
	P	Q	T	RH	GW	Rad(2)	OVA	HC
	1/day	1/day	1/day	1/day	1/day	1/day	1/day	1/day
Location								
AV1	X	X					X	X
APM1	X							
APM2	X							
APM3	X							
AI1	X							
SV1	X	X			X		X	X
SPM1	X							
SPM2	X							
SI1	X				X			
Dilution Air Line	X	X	X	X				
Vapor Manifold	X		X	X				
B-1 Out	X		X	X			X	X
GAC-1 Out	X						X	X
GAC-2 Out	X						X	X
Stack	X	X	X			X	X	

NOTES:

(1)- The pilot testing schedule may require adjustment in the field based on available manpower resources.

(2) - Sampling of exhaust gas for subsequent alpha radiation measurement is continuous. The "Rad" measurement frequency interval indicated corresponds to benchtop measurement of the sample filter media for alpha activity.

P - Pressure
Q - Flow rate
T - Temperature
RH - Relative humidity (moisture content)
GW - Groundwater level
Rad - Radiation
OVA - Field organic vapor analyzer
HC - Hydrocarbon sample (GC measurement)

9) **TABLE 7-9 Sustained Operations - Schedule of Measurements**

7.5 DATA COLLECTION PROCEDURES

This subsection provides the procedures that will be employed to monitor the operating conditions of the system at the sampling ports provided in the vapor manifold. In-line monitoring devices will be present in the vapor extraction unit. These procedures will be used for the pilot tests as well as the sustained operations.

7.5.1 Static Pressure

Static pressure will be monitored using EPA Source Test Method 2 (EPA, 1988). A magnehelic gauge will be used to measure the differential pressure across a flexible diaphragm. One side of the diaphragm is at atmospheric pressure, and the other side is at the system pressure. The static pressure is obtained by inserting the rigid probe end of the tubing into the sample port. The needle deflection on the gauge, due to the movement of the diaphragm, indicates the static pressure. Static pressure monitor will be installed upstream and downstream of the HEPA filters. When the differential pressure across a HEPA filter is 1-inch Hg greater than the differential pressure across a new filter (at approximately the same flow rate), the "spent" filter cartridge will be replaced. The mobile vapor extraction pilot unit is equipped with two HEPA filters configured in parallel to allow for cartridge replacement without interruption of system operation.

7.5.2 Flow Rate

The flow rate will be measured in accordance with EPA Source Test Method 2 (EPA, 1988). The flow rate will be calculated from the velocity pressure. Specifically, the velocity pressure will be converted to the air velocity. This is multiplied by the cross-sectional area of the pipe to obtain the air flow rate. The velocity pressure (also known as the dynamic pressure) is the difference of the total pressure and the static pressure.

7.5.3 Temperature and Moisture

Temperature and moisture measurements will be obtained using EPA Source Test Methods 2 and 4, respectively. A temperature probe will be inserted in the air stream, and after the reading stabilizes the temperature will be recorded from the instrument display. Moisture determination involves extracting a known volume of vapor from the system, condensing out the moisture, and calculating the moisture content based on the mass balance.

7.5.4 Subsurface Static Pressure

The subsurface static pressure will be measured using the same equipment as for static pressure measurement, except that the metal probe is not employed. The flexible tubing will be attached to the cap of the PM probe, and the deflection of the needle on the magnehelic gauge will be recorded.

7.5.5 Ground-Water Level

The ground-water levels in the sandstone vapor extraction vent and in the sandstone air injection vent will be measured using a water level indicator. The water level is obtained by lowering the probe end and associated cable of the water level indicator into the vent through the designated port. When the water table is reached, a light is activated on the hand-held portion of the water level indicator. The depth to ground water can then be read from the indicator cable (readings are to be made at the sample port opening).

7.5.6 Removed Organics Concentration

The contaminant concentration measurement for the SVE system will be performed using a monitoring instrument such as an OVA or HNu and a combustible gas indicator, and by collecting air samples for on-site analysis. The monitoring instruments provide real time data and give results that are based on their associated calibration gas, i.e., their readings are not compound-specific.

The air samples for on-site analysis will be collected from ports on the system using EPA Standard Test Method 18. Method 18 allows for several sample collection methods including integrated bag sampling, direct interface sampling, dilution interface sampling, and adsorbent sampling. In all cases, a known quantity of air will be drawn into the collection bag or through the collection media, and the compounds of concern are captured. All methods except absorbent collection allow for direct injection into the GC. Method 18 describes the strengths and weaknesses of each collection method. A determination of the most appropriate method will be made during the system pilot tests, although integrated bag sampling or adsorbent sampling are expected to be the most appropriate.

All air samples from the SVE system will be analyzed for TCE, PCE, chloroform, and carbon tetrachloride. In addition, 10 percent of the samples will be analyzed for all VOCs. Contaminant concentrations and mass removal rates will be calculated from the analytical results.

7.5.7 Radiation Measurement Operating Procedure

This subsection describes the procedures that will be used to verify that the treated vapor stream discharged from the pilot unit is free of radionuclide-contaminated particulates. This procedure, based on the observational approach, uses data collected early in the pilot test to develop pilot unit operational guidance.

At the start of the first pilot test, the exhaust gas metering pump will be adjusted to deliver a flow rate of 10 liters/min, and the valves will be manually set to direct this flow to one of the sample tubes. After 2 hours of operation, the pressure drop across the sample filter will be recorded in the field logbook. The sampling system valves will then be set to direct the gas flow to the alternate sample tube. The HEPA filter from the first tube will then be removed and immediately scanned for alpha activity with the benchtop meter (see Subsection 6.7.1). If the alpha activity on the filter media exceeds four times the background level (alarm level), the pilot system will be shut down. The sample filter will continue to be scanned once every 30 minutes for a period of no longer than 8 hours. The alpha measurements obtained at 30-minute intervals will be recorded in the field logbook. If during the 8-hour period, the alpha radiation levels decrease to background levels (indicating that the source of the detected alpha radiation is natural, short-lived species, e.g., radon decay products), the vapor extraction unit will be restarted. If after 8 hours the alpha radiation levels do not decrease to background, the HEPA filter will be analyzed at an off-site laboratory for the presence of plutonium (Pu), americium (Am), and uranium (U). Decisions regarding continued pilot testing and/or pilot system modifications will be made by the EG&G Project Manager based on the species-specific analytical results.

The pilot system shutdown procedure will be executed for the first five times the alpha alarm level is detected on the HEPA filter media. If these five instances prove that the elevated levels of alpha activity was due to the presence of natural species, future exceedances of the alarm level will not be accompanied by a system shutdown. Rather, the pilot unit will be allowed to continue to operate while the filter media is scanned to verify a short-lived decay. If the expected decay is not observed within a 4-hour period, the shutdown procedure described above will be executed.

In the likely event that a HEPA filter that has sampled the exhaust gas for 2 hours shows no elevated levels of alpha activity, the sample filter will be returned to the sample tube from which it was removed. After the alternate HEPA filter has sampled the exhaust gas for a 2-hour period, flow will be directed to the first sample tube, and the alternate filter will be scanned for alpha activity. This sampling and measurement sequence with the parallel tubes will be initially repeated every hour. After the pilot unit has established a radionuclide-free exhaust gas "track record," the measurement interval may be increase at the discretion of the EG&G Project

Manager. It is important to note that the parallel sample tube configuration allows continuous sampling of the exhaust gas.

The pressure drop across the HEPA sample filters will be recorded daily in the field logbook. If during system operation the pressure drop across a HEPA sample filter increases 1 inch of water column above the pressure drop across the filter when it was originally placed into service, the filter will be replaced. The spent filter will be discarded per RFP standard waste management operating procedures. A sample filter, spent or otherwise, will be subjected to isotope-specific laboratory analysis only if field measurement indicates that non-shortlived radioactive species are present.

The HEPA filters will be visually inspected on a daily basis to assess particulate loading and filter integrity (e.g., cracks, leaks, etc). Filters will be replaced as required.

7.5.8 <u>Air Permeability Determination</u>

Air permeability tests (Pilot Test Nos. 2 and 3) will be conducted to determine the air permeability at different vent pressures, and therefore allow air flow modeling. The procedures utilized to conduct air permeability tests are described in "Guide to Conducting Treatability Studies under CERCLA: Soil Vapor Extraction; Interim Guidance" (EPA, 1991b). The subsurface pressure at the PM probes will be is monitored over time, holding the vent pressure constant. By plotting the PM probe pressure as a function of time, the permeability will be calculated based on the slope of the best-fit line.

7.5.9 <u>GAC Capacity Estimation</u>

The performance of the vapor-phase GAC units will be estimated based on the results obtained throughout the duration of all nine system pilot tests. System variables, such as relative humidity and temperature of the extracted vapor stream, will affect the performance of the GAC units. Contaminant mass removal rates will determine the mass loading rate. GAC isotherms for the compounds extracted will be utilized to estimate the carbon unit lifetime.

In addition to computing an estimate of GAC unit lifetime, GAC unit lifetime will also be determined by direct measurement. The contaminant concentration data obtained from sample ports SP-1, SP-2, and SP-3 (B-1 Out, GAC-1 Out, and GAC-2 Out, respectively) will be analyzed for VOC breakthrough. Breakthrough will be defined as the time when the VOC concentration exiting GAC-1 (GAC-1 Out) is 95 percent of the VOC concentration entering GAC-1 (B-1 Out) or when any VOCs are detected exiting GAC-2 (GAC-2 Out). From this information, the capacity of GAC-1 will be estimated (i.e., the total amount of contaminant the unit has adsorbed). When breakthrough occurs, GAC-1 will be removed from the system and replaced by a new lead GAC unit. GAC-2 will be moved to become the lead GAC unit, however, if an estimated 50 percent of its capacity has been used at the time of lead GAC unit replacement. The new GAC unit will then be installed as the polishing GAC unit. This will ensure that the polishing GAC unit always maintains a minimum of 50 percent of unused adsorption capacity.

Project Manager

Quality Assurance Program Manager

SECTION 8
DATA EVALUATION AND REPORTING

8.1 PRESENTATION OF DATA

Field data will be reported in a concise manner during the Pilot Test and Sustained Operations Project Phases, thereby facilitating subsequent data interpretation. The following subsections provide guidance for the presentation and interpretation of the pilot test data.

8.1.1 Pilot System Operations

Data collected during system pilot tests will be recorded in the field logbook and/or data collection sheets. Such data will be checked and tabulated subsequent to completion of each pilot test. Individual data tables will be created for each series of measurements associated with a specific vent operating pressure (pilot test runs), and will include the following information (where applicable):

- Date, time, number, and run of pilot test.
- Duration of the test run.
- Extraction vent identification.
- Extraction vent operating pressure.
- Extraction vent air flow rates.
- Depth to ground water.
- Subsurface pressures measured at PM probes (location specified).
- Contaminant concentrations and composition of the extracted vapor stream.

- Contaminant mass removal rate.
- Cumulative mass removal.

The time of each measurement will also be incorporated into the data tables. All deviations from expected conditions (e.g., inclement weather, ground-water table fluctuations, equipment operations) will be noted.

Subsurface pressures, measured at PM probes, will be plotted as a function of distance from associated extraction vents. For Pilot Test Nos. 2 through 9, one such plot will be created for each operating vent pressure of the individual pilot test. These plots, through curve fitting, will provide measured radius of influence information.

For Pilot Test Nos. 2 and 3, radial subsurface pressures will be plotted versus the natural logarithm of time as described in "Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction; Interim Guidance" (EPA, 1991b). Individual plots will be prepared for each vent operating pressure of each pilot test for a total of three plots to be generated per pilot test. Pilot Test No. 2 plots will include pressure data measured from APM1, APM2, APM3, and AI1. Pilot Test No. 3 plots will include pressure data measured from SPM1, SPM2, and SI1.

8.1.2 <u>Sustained Operations</u>

Data collected during the sustained operations period will be recorded in the field logbook. Such data will be tabulated subsequent to completion of each week of sustained operations. Data tables will be created for each week of sustained operations, and will include the following information (where applicable):

- Date and time of measurement.
- Extraction vent operating pressures.

- Extraction vent air flow rates.
- Depth to ground water.
- Subsurface pressures measured at PM probes (location specified).
- Ground-water extraction rates.
- Moisture content of the extracted vapor stream.
- Volume of water removed from the extracted vapor stream.
- Contaminant concentrations and composition of the extracted vapor stream.
- Contaminant mass removal rate.
- Cumulative mass removal.

All deviations from expected conditions (e.g., inclement weather, ground-water table fluctuations, equipment operations) will be noted.

Plots of individual vent operating pressures and flow rates versus time will be prepared at the end of the sustained operations period. Plots of subsurface pressures versus time and versus distance from associated extraction vents will also be prepared at the end of the sustained operations period. In addition, plots of individual and cumulative contaminant removal rates versus time will be prepared following each week of sustained operations. A summary of all weekly plots will be prepared following the sustained operations period.

8.2 DATA INTERPRETATION AND ANALYSIS

The data collected during pilot operations will be used to evaluate the applicability of SVE technology to treat subsurface contamination at T-4. In addition, such data will provide the site-specific information necessary to support FS evaluation of SVE technology as a remedial action alternative for subsurface contamination at the East Trenches Area.

8.2.1 Pilot System Operations

The data collected during pilot tests will show the effects of varying vent pressures, passive air inlet, and air injection. Radius of influence, air permeability, and contaminant removal rates are all expected to vary as these operating conditions change. During analysis of the pilot test data, this information will be analyzed in an attempt to determine, mathematically if possible, the effects of these operation variations. As an example, the pressure distribution equation (previously discussed in Section 3) will be applied to determine if radial flow patterns are achieved.

The air permeabilities of both the alluvium and the sandstone will be estimated from previously constructed plots of subsurface pressure versus the natural logarithm of time. For example, to estimate the air permeability of the alluvium for a given vent operating pressure, a straight line will be fitted through the data of each PM probe in the respective Pilot Test No. 2 plot from which the slopes and y-intercepts will be read. This information will then be used to estimate the permeability of the alluvium at a given vent operating pressure to air flow following procedures outlined in "Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction; Interim Guidance" (EPA, 1991b). This procedure will then be repeated for each vent operating pressure of Pilot Test No. 2 (total of 3 plots). This procedure will be repeated using Pilot Test No. 3 plots to estimate the permeability of the sandstone to air flow. Permeabilities to air flow will be reported as ranges.

The effect of sandstone dewatering will also be analyzed. The data collected during the pilot tests will show whether dewatering is beneficial. A detailed discussion and comparison of saturated versus unsaturated zone venting will be provided.

8.2.2 Sustained Operations

Data obtained during sustained operations will be used to estimate the system's projected cumulative and individual (i.e., alluvium versus sandstone) contaminant removal rates, and the individual radius of influences for alluvium and sandstone extraction vents. Of particular importance will be the interpretation of weekly plots of individual and cumulative contaminant removal rates versus time. To estimate the system's projected contaminant removal rates, curves (i.e., regression analysis) may be fitted to the plots of contaminant removal rates versus time. Curves will only be fitted to mass removal rate data from the soil-vapor equilibrium point to the end of the sustained operations period. These fitted curves will be used to predict contaminant removal rates and residual soil concentrations as a function of treatment time.

Operating costs for the system will be prepared from data obtained during the sustained operations period. The cost estimates will be presented as follows:

- Cost per pound of contaminant removed.
- Cost per cubic yard of soil remediated.
- Cost per volume of air extracted.

SECTION 9

SCHEDULE

A proposed schedule for the planning and implementation of the SVE pilot test at the East Trenches Area (i.e., IHSS No. 111.1) is presented in Table 9-1. Table 9-1 presents specific completion dates for Subsurface IM/IRA activities leading up to the startup of the pilot unit at IHSS No. 111.1. Due to the uncertainty associated with the actual length of time that will be required to complete the pilot test, estimated time durations are listed in lieu of specific completion dates for activities conducted subsequent to "System Operations Testing/Begin Pilot Testing."

Table 9-1

Proposed Schedule
East Trenches Area Pilot Test
Subsurface IM/IRA
Operable Unit No. 2

Activity	Date
Submit Draft Test Plan to EPA/CDH	29 October 1992
EPA/CDH Comments on Draft Test Plan	26 November 1992
Submit Final Test Plan to EPA/CDH and Complete Site 1 Bid Package	12 January 1993
Solicit and Complete Evaluation of Subcontractor Bids/Issue Purchase Order	09 March 1993
Finalize Subcontractor Design Drawings/ EG&G Issues Authorization to Proceed	26 April 1993
Complete Pilot Unit Installation	03 August 1993
Complete Inspection and System Operations Testing/ Begin Pilot Testing	15 September 1993
Complete Pilot Study	13 weeks after Pilot Study begins
Submit Draft Pilot Test Report to EPA/CDH[a]	24 weeks after Pilot Study concludes
EPA/CDH Comments on Draft Pilot Test Report	3 weeks after receipt of Draft Test Report
Submit Final Pilot Test Report to EPA/CDH	4 weeks after receipt of EPA/CDH comments on Draft Test Report

[a] Schedule assumes 80 days for turnaround of analytical laboratory data.

APPENDIX A

ENGINEERING DRAWINGS

APPENDIX B

[RESERVED FOR FUTURE USE]

APPENDIX C

SOIL BORING LOGS

STATE PLANE COORDINATE:		TOTAL DEPTH (FT): 26		GROUND ELEVATION (FT):	5969.4	PROJECT NUMBER:	667.11
NORTH:	749502	AREA: MOUND AREA		CASING DIAMETER (IN):	0	GEOLOGIST:	DCB
EAST:	2086149	LOCATOR NUMBER:	N9	BOREHOLE DIAMETER (IN):	0	DATE DRILLED:	07/20/87

LOG OF BORING NUMBER:

BH36-87

REMARKS: Hollow Stem Auger. BH backfilled w/ Portland Type I cement.

CHEMICAL SAMPLE DEPTH / GRADATIONAL DEPTH	SAMPLE NUMBER	SAMPLE GRAIN SIZE (0% 50% 100%)	PERCENT RECOVERY (0% 100%)	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
				0.6/1.3	5969	0			CL:	GRAVELLY CLAY - pale yellowish brown (10YR 6/2), low plasticity, abundant carbonate mineralization, some plant debris, caliche rind occurs in gravel.
				0/0.7	5968	1			NO SAMPLE:	
	BH36870005			1.3/2	5967 / 5966	2 / 3			CL:	As above (reference interval 0.0 to 1.3), clay component decreases below 3 ft. and is replaced by caliche.
	BH368705AS			0/1.3	5965	4 / 5			NO SAMPLE	
				0/0.7	5964				NO SAMPLE	
				0.35/0.6	5963	6			GC	Clayey Gravel - medium gray (N5), clay matrix is grayish orange (10YR 7/4), angular, poorly graded, max size 5.5 cm, some silt
	BH36870515			0/3.4	5962 / 5961 / 5960	7 / 8 / 9 / 10			NO SAMPLE	

STATE PLANE COORDINATE:	TOTAL DEPTH (FT): 26	GROUND ELEVATION (FT): 5969.4	PROJECT NUMBER: 667.11	LOG OF BORING NUMBER:
NORTH: 749502	AREA: MOUND AREA	CASING DIAMETER (IN): 0	GEOLOGIST: DCB	BH36-87
EAST: 2086149	LOCATOR NUMBER: N9	BOREHOLE DIAMETER (IN): 0	DATE DRILLED: 07/20/87	

REMARKS: Hollow Stem Auger. BH backfilled w/ Portland Type I cement.

SAMPLE NUMBER	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
BH36870515	0/0.6	5959	10		NO SAMPLE	
	0/1.4	5958	11		NO SAMPLE	
	0/0.65	5957	12		NO SAMPLE	
	0/3.55	5956–5953	13–16		NO SAMPLE	
	0.8/1.5	5953–5952	16.2–17.7		GC	Clayey Gravel - medium gray (N5), clay matrix is grayish orange (10YR 7/4), angular to sub-rounded, poorly sorted, max. size 4 cm
	0/1.5	5951	17.7–19.2		NO SAMPLE	
BH36870720CT	0.5/1.2	5950	19.2–20		GC	As above (reference interval 16.2 to 17.7 ft), max. gravel size is 2.5 cm

STATE PLANE COORDINATE:	TOTAL DEPTH (FT): 26	GROUND ELEVATION (FT):	5969.4	PROJECT NUMBER:	667.11
NORTH: 749502	AREA: MOUND AREA	CASING DIAMETER (IN):	0	GEOLOGIST:	DCB
EAST: 2086149	LOCATOR NUMBER: N9	BOREHOLE DIAMETER (IN):	0	DATE DRILLED:	07/20/87

LOG OF BORING NUMBER:

BH36-87

REMARKS: Hollow Stem Auger. BH backfilled w/ Portland Type I cement.

DEPTH (FT)	DATUM (FT)	RECOVERY/INTERVAL	SAMPLE NUMBER	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
20.6		0.6 /0.6		CLAYSTONE:	Top of Bedrock Grades to claystone.
21.0		0.9 /1.2		CLAYSTONE:	Light olive gray (5Y 6/1), high plasticity, localized iron staining.
22.2		0 /0.79		NO SAMPLE:	
23.0		0.6 /1.5	BH3687230R	CLAYSTONE:	As above (reference interval 20.6 to 22.2 ft.).
24.5		1.5 /1.5		CLAYSTONE:	As above. NOTE: No water encountered while drilling.

Column headings: CHEMICAL SAMPLE DEPTH / GRADATIONAL SAMPLE DEPTH; SAMPLE NUMBER; SAMPLE GRAIN SIZE (0% 50% 100%); PERCENT RECOVERY (0% 100%); RECOVERY/INTERVAL; DATUM (FT); DEPTH (FT); WELL OR PIEZOMETER CONSTRUCTION; LITHOLOGY; UNIFIED SOILS CLASSIFICATION OR ROCK TYPE; DESCRIPTION

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

Datum scale: 5949, 5948, 5947, 5946, 5945, 5944, 5943, 5942, 5941, 5940

STATE PLANE COORDINATE:	TOTAL DEPTH (FT): 74.5	GROUND ELEVATION (FT): 5949.04	PROJECT NUMBER: 667.11
NORTH: 749979	AREA: EAST TRENCHES	CASING DIAMETER (IN): 2 ID	GEOLOGIST: DCB
EAST: 2087295	LOCATOR NUMBER: 09	BOREHOLE DIAMETER (IN): 7.5	DATE DRILLED: 08/27/87
REMARKS: Hollow Stem Auger.			

LOG OF BORING NUMBER:

36-87BR

SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
		1.3 /2	5949	0	GC:	Clayey Gravel - light gray (N7), clay matrix is dark yellowish brown (10YR 4/2), angular, moderately sorted, max. size 5.5 cm., some plant debris in upper 0.3 ft.
			5948	1		
		2 /2	5947	2	GC:	GRAVEL - light gray (N7), angular to sub-angular, moderately sorted, max. size 4.5 cm., caliche matrix.
			5946	3		
		0.5 /0.5	5945	4	GC:	As above, gravel fraction is coarser, max size 6 cm., some sand.
		0 /0.5			NO SAMPLE:	
		1.5 /1.5	5944	5	GC	Clayey Gravel - light gray (N7), clay matrix is light brown (5YR 5/6), angular to sub-rounded, poorly graded, max. size 5.5 cm., some sand, caliche rind on gravel.
			5943	6		
		0 /0.5			NO SAMPLE	
		2 /2	5942	7	SP	GRAVELLY SAND - grayish orange (10YR 7/4), coarse grained to very fine grained, poorly graded, angular to sub-angular, some clay and calcareous mineralization
					CLAYSTONE:	Top of Bedrock Very light gray (N7), high plasticity (est.) local iron staining and bodies of caliche, some silt and stringers
			5941	8		
		2 /2	5940	9	CLAYSTONE	As above, caliche bodies/stringers less frequent below 10 ft
				10		

Column headings also printed: CHEMICAL SAMPLE DEPTH; GRADATIONAL DEPTH; SAMPLE NUMBER; WELL OR PIEZOMETER CONSTRUCTION; LITHOLOGY. Grain size scale: 0% 50% 100%; recovery scale: 100% 0% 100%.

STATE PLANE COORDINATE:	TOTAL DEPTH (FT): 74.5	GROUND ELEVATION (FT):	5949.04	PROJECT NUMBER:	667.11
NORTH: 749979	AREA: EAST TRENCHES	CASING DIAMETER (IN):	2 ID	GEOLOGIST:	DCB
EAST: 2087295	LOCATOR NUMBER: 09	BOREHOLE DIAMETER (IN):	7.5	DATE DRILLED:	08/27/87

LOG OF BORING NUMBER:

36-87BR

REMARKS: Hollow Stem Auger.

GRADATIONAL ... DEPTH	SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
		0% 50% 100%	0% 100%	2/2	5939	10				
					5938	11			CLAYSTONE:	As above at 12 ft. (est.depth) interval grades to very pale orange (10YR 8/2).
				2/2	5937	12				
					5936	13			CLAYSTONE:	As above.
				2/2	5935	14				
					5934	15			CLAYSTONE:	As above
				2/2	5933	16			CLAYSTONE:	Light gray (N7), bedding not apparent (massive?), highly weathered, moderately friable, localized iron staining.
					5932	17			CLAYSTONE:	As above
				2/2	5931	18				
					5930	19			CLAYSTONE:	As above, below 20 ft. (est. depth) interval grades from claystone to siltstone to sandstone.
				2/2		20				

STATE PLANE COORDINATE:		TOTAL DEPTH (FT): 74.5	GROUND ELEVATION (FT):	5949.04	PROJECT NUMBER:	667.11	LOG OF BORING NUMBER:
NORTH:	749979	AREA: EAST TRENCHES	CASING DIAMETER (IN):	2 ID	GEOLOGIST:	DCB	36-87BR
EAST:	2087295	LOCATOR NUMBER: 09	BOREHOLE DIAMETER (IN):	7.5	DATE DRILLED:	08/27/87	

REMARKS: Hollow Stem Auger.

CHEMICAL SAMPLE DEPTH / GRADATIONAL DEPTH | SAMPLE NUMBER | SAMPLE GRAIN SIZE (0% 50% 100%) | PERCENT RECOVERY (0% 100%) | RECOVERY/INTERVAL | DATUM (FT) | DEPTH (FT) | WELL OR PIEZOMETER CONSTRUCTION | LITHOLOGY | UNIFIED SOILS CLASSIFICATION OR ROCK TYPE | DESCRIPTION

Sample number	Recovery/Interval	Datum (ft)	Depth (ft)	Unified soils classification or rock type	Description
	2/2	5929	20		
	0.5/0.5	5928	21	SANDSTONE:	Yellowish gray (5Y 7/2), bedding not apparent, may be horizontal from appearance of core breaks, highly weathered, moderately friable, fine grained, sub-angular to sub-rounded, well sorted, localized to wide spread iron staining.
	1.5/1.5	5927	22	SANDSTONE:	As above.
	1.5/1.5	5926	23	SANDSTONE:	As above.
		5925	24		
	1.5/1.5	5924	25	SANDSTONE:	As above.
UNK	1.5/1.5	5923	26	SANDSTONE:	As above.
		5922	27		
	1.5/1.5	5921	28	SANDSTONE:	As above
	1.5/1.5	5920	29	SANDSTONE:	As above.
			30		

STATE PLANE COORDINATE:	TOTAL DEPTH (FT): 74.5	GROUND ELEVATION (FT): 5949.04	PROJECT NUMBER: 667.11	LOG OF BORING NUMBER:
NORTH: 749979	AREA: EAST TRENCHES	CASING DIAMETER (IN): 2 ID	GEOLOGIST: DCB	36-87BR
EAST: 2087295	LOCATOR NUMBER: 09	BOREHOLE DIAMETER (IN): 7.5	DATE DRILLED: 08/27/87	

REMARKS: Hollow Stem Auger.

CHEMICAL DATA / GRADATIONAL DEPTH / SAMPLE NUMBER / SAMPLE GRADATION SIZE (0% 50% 100%) / PERCENT RECOVERY (0% 100%) / RECOVERY/INTERVAL / DATUM (FT) / DEPTH (FT) / WELL OR PIEZOMETER CONSTRUCTION / LITHOLOGY / UNIFIED SOILS CLASSIFICATION OR ROCK TYPE / DESCRIPTION

Water levels: 12/01/87 (about 31.8 ft); 08/27/87 (35 ft)

Depth (ft)	Datum (ft)	Recovery/Interval	Rock Type	Description
30–30.5	5919			
30.5–32.5	5918–5917	2 /2	SANDSTONE:	As above, at about 31 ft. bedding becomes distinct, 2 mm. and less in thickness.
32.5–34	5916	1.5 /1.5	SANDSTONE:	As above.
34–35.5	5915–5914	1.5 /1.5	SANDSTONE:	As above, at about 34.5, bedding thickness increases to 5 mm. and less, medium grained fraction present.
35.5–37	5913	1.5 /1.5	SANDSTONE:	Very light gray (N8) and grayish orange (10YR 7/4), bedding not apparent, highly weathered, highly friable, very fine grained to fine grained, poorly sorted, localized to widely disseminated iron staining.
37–38.5	5912–5911	1.5 /1.5	SANDSTONE	As above
38.5–40	5910	1.5 /1.5	SANDSTONE:	As above

STATE PLANE COORDINATE:	TOTAL DEPTH (FT): 74.5	GROUND ELEVATION (FT): 5949.04	PROJECT NUMBER: 667.11
NORTH: 749979	AREA: EAST TRENCHES	CASING DIAMETER (IN): 2 ID	GEOLOGIST: DCB
EAST: 2087295	LOCATOR NUMBER: 09	BOREHOLE DIAMETER (IN): 7.5	DATE DRILLED: 08/27/87

REMARKS: Hollow Stem Auger.

LOG OF BORING NUMBER:

36-87BR

SAMPLE NUMBER	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
	1.5/1.5	5909	40	SANDSTONE	As above.
	0.9/1.5	5908	41.5	SANDSTONE	At 42 ft. (est depth), interval grades to medium grained, well rounded sandstone.
UNK	1/1	5906	43	SANDSTONE	As above.
	0.7/1.5	5905	44	SANDSTONE	As above.
	1.5/1.5	5904	45	SILTSTONE	Interval grades to siltstone below 45 ft, light gray (N7), well weathered, moderate to slightly friable, slight VFG sand fraction.
	0.3/1	5902	47	SILTSTONE	As above
	0/1	5901	48	NO SAMPLE	
	0.5/0.5	5900	49	SILTSTONE	As above (reference interval 45.5 to 47.0 ft.).
	0.5/0.5		49.5	SILTSTONE	As above.

Column headings: CHEMICAL SAMPLE DEPTH, GRADATIONAL SAMPLE DEPTH, SAMPLE NUMBER, SAMPLE GRAIN SIZE (0% 50% 100%), PERCENT RECOVERY (0% 100%), RECOVERY/INTERVAL, DATUM (FT), DEPTH (FT), WELL OR PIEZOMETER CONSTRUCTION, LITHOLOGY, UNIFIED SOILS CLASSIFICATION OR ROCK TYPE, DESCRIPTION

Depth scale: 40 41 42 43 44 45 46 47 48 49 50
Datum scale: 5909 5908 5907 5906 5905 5904 5903 5902 5901 5900

STATE PLANE COORDINATE:	TOTAL DEPTH (FT): 74.5	GROUND ELEVATION (FT):	5949.04	PROJECT NUMBER:	667.11
NORTH: 749979	AREA: EAST TRENCHES	CASING DIAMETER (IN):	2 ID	GEOLOGIST:	DCB
EAST: 2087295	LOCATOR NUMBER: 09	BOREHOLE DIAMETER (IN):	7.5	DATE DRILLED:	08/27/87

REMARKS: Hollow Stem Auger.

LOG OF BORING NUMBER:

36-87BR

CHEMICAL SAMPLE DEPTH / GRADATIONAL SAMPLE DEPTH | SAMPLE NUMBER | SAMPLE GRAIN SIZE (0% 50% 100%) | PERCENT RECOVERY (0% 100%) | RECOVERY/INTERVAL | DATUM (FT) | DEPTH (FT) | WELL OR PIEZOMETER CONSTRUCTION | LITHOLOGY | UNIFIED SOILS CLASSIFICATION OR ROCK TYPE | DESCRIPTION

Depth (ft)	Datum (ft)	Recovery/Interval	Unified Soils Classification or Rock Type	Description
50	5899	1/1	CLAYSTONE:	Medium light gray (N6), bedding not apparent (massive?), well weathered, moderately to slightly friable, slight silt fraction.
51	5898	1.5/1.5	CLAYSTONE:	As above.
52	5897	0.3/0.29	SILTY SANDSTONE:	Very pale orange (10YR 8/2), bedding not apparent (massive?), highly weathered, moderately friable, very fine grained, localized iron staining.
53	5896	0.5/1	SILTY SANDSTONE:	As above.
54	5895	1.7/1.7	SILTY SANDSTONE:	As above.
55	5894	0/0.5	NO SAMPLE:	
56	5893	1/1	SILTY SANDSTONE:	As above (reference interval 52 to 55.5)
57	5892	1/1	SILTY CLAYSTONE:	Very light gray (N8), weathered, slightly friable, interval grades to sandstone, dark yellowish orange (10YR 6/6), bedding not apparent (massive?), well weathered, moderately friable, very fine grained with abundant silt.
58	5891	2/2	SANDSTONE:	Grayish orange (10YR 7/4), bedding not apparent (massive?), highly weathered, slightly friable, some silt, interval grades to medium grained to very fine grained, well rounded, moderate sorting and highly friable
59	5890			
60				

STATE PLANE COORDINATE:	TOTAL DEPTH (FT): 74.5	GROUND ELEVATION (FT): 5949.04	PROJECT NUMBER: 667.11	LOG OF BORING NUMBER:
NORTH: 749979	AREA: EAST TRENCHES	CASING DIAMETER (IN): 2 ID	GEOLOGIST: DCB	36-87BR
EAST: 2087295	LOCATOR NUMBER: 09	BOREHOLE DIAMETER (IN): 7.5	DATE DRILLED: 08/27/87	

REMARKS: Hollow Stem Auger.

DEPTH (FT)	DATUM (FT)	RECOVERY/INTERVAL	SAMPLE NUMBER	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
60	5889	0.7/1		SANDSTONE:	As above.
61	5888	0.7/1		SANDSTONE:	As above.
62	5887	0.5/0.5		SANDSTONE:	As above.
		0.5/0.5		SANDSTONE:	Dark yellowish orange (10YR 6/6), bedding not apparent (massive?), well weathered, moderately to highly friable, very fine grained, well sorted, moderate silt fraction.
63	5886	3.5/3.5	UNK	CLAYSTONE:	Medium light gray (N6), bedding not apparent (massive?), well weathered, moderately friable, localized iron staining and carbonaceous mineralization. Interval grades to clayey siltstone with depth.
64	5885				
65	5884				
66	5883	0.35/0.5		CLAYEY SILTSTONE:	Med. light gray, massive bedding, well weathered, slightly friable, trace of carbonaceous and iron staining.
67	5882	0.75/1		SANDSTONE:	Fine grained, mottled, very light gray (N8) and very pale orange (10YR 8/2), massive bedding, highly weathered, mod. friable, well sorted, becoming clayey at bottom of interval.
68	5881	0/2.5		NO SAMPLE:	
69	5880				
70					

Column headings: CHEMICAL SAMPLE DEPTH, GRADATIONAL SAMPLE DEPTH, SAMPLE NUMBER, SAMPLE GRADATION SIZE (0% 50% 100%), PERCENT RECOVERY (0% 100%), RECOVERY/INTERVAL, DATUM (FT), DEPTH (FT), WELL OR PIEZOMETER CONSTRUCTION, LITHOLOGY, UNIFIED SOILS CLASSIFICATION OR ROCK TYPE, DESCRIPTION

STATE PLANE COORDINATE:
NORTH: 749979
EAST: 2087295
REMARKS: Hollow Stem Auger.

TOTAL DEPTH (FT): 74.5
AREA: EAST TRENCHES
LOCATOR NUMBER: 09

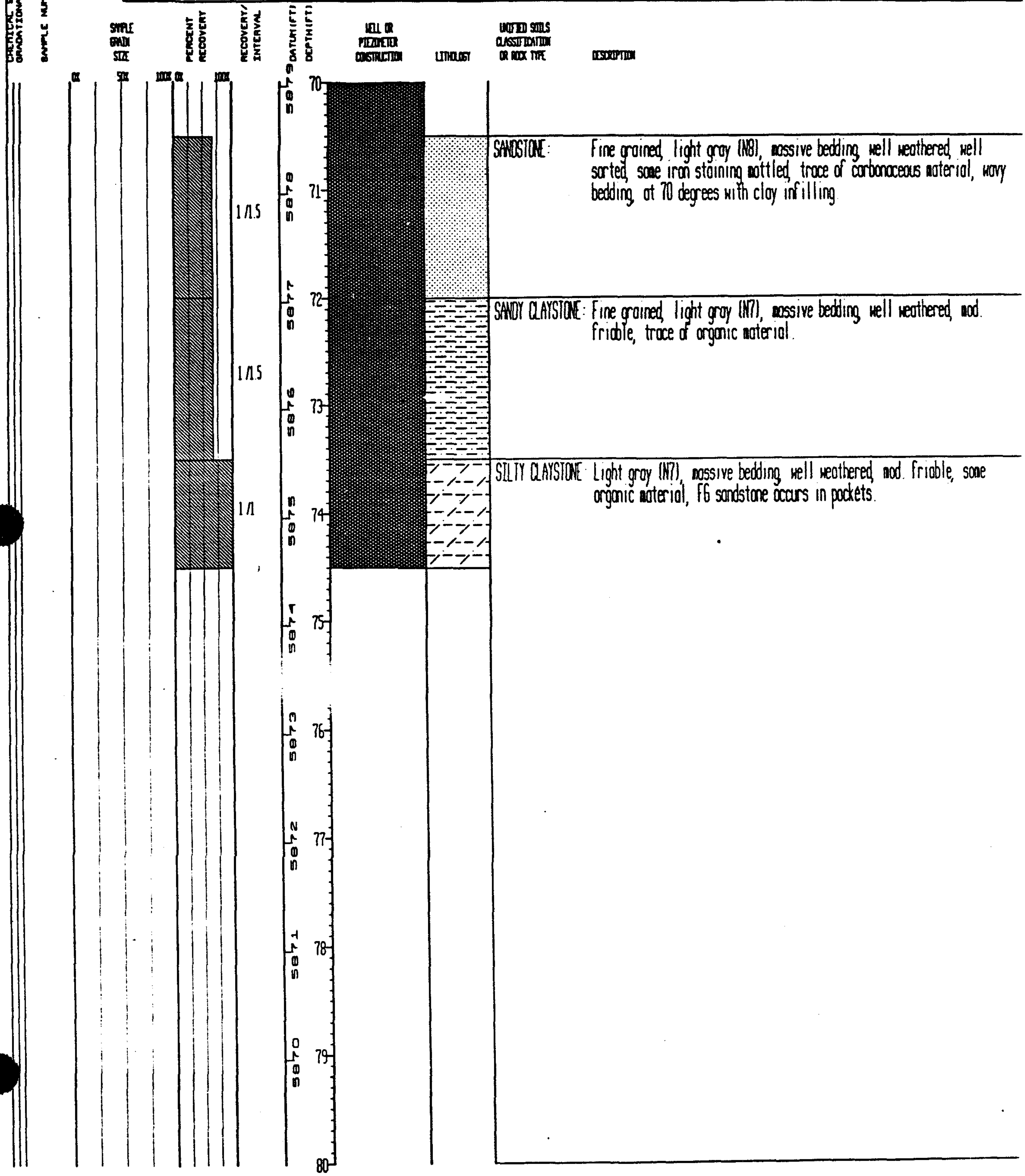
GROUND ELEVATION (FT): 5949.04
CASING DIAMETER (IN): 2 ID
BOREHOLE DIAMETER (IN): 7.5

PROJECT NUMBER: 667.11
GEOLOGIST: DCB
DATE DRILLED: 08/27/87

LOG OF BORING NUMBER:

36-87BR

DEPTH (FT)	DATUM (FT)	RECOVERY/ INTERVAL	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
70.5–72		1/1.5	SANDSTONE:	Fine grained, light gray (N8), massive bedding, well weathered, well sorted, some iron staining mottled, trace of carbonaceous material, wavy bedding, at 70 degrees with clay infilling.
72–73.5		1/1.5	SANDY CLAYSTONE:	Fine grained, light gray (N7), massive bedding, well weathered, mod. friable, trace of organic material.
73.5–74.5		1/1	SILTY CLAYSTONE:	Light gray (N7), massive bedding, well weathered, mod. friable, some organic material, FG sandstone occurs in pockets.



ROCKY FLATS PLANT BOREHOLE LOG

FORM GT.1A

Borehole Number: 10291
Location - North: East:
Date: 12/6/91
Geologist: LVS/LAG
Drilling Equip.: CME 75

Surface Elevation:
Area: NE TRENCHES
Total Depth: 60.0
Company: EGG
Project No.: OU2 RFI RI PH II
Sample Type: continuous core

EG&G LOGGING SUPERVISOR
APPROVAL [signature]
DATE 12/23/91

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	SAMPLE DESCRIPTION
										0.9 START CORING
Box 1 of 5	Run 1 / 2.0	0.5				71% Gravel 25% Sand 4% clay 1% silt	GW	1 / .4		Sandy Gravel - Moderate brown (5YR 3/4), max size gravel 1½" diameter, average ½" diameter, coarse to medium-grained sand, well graded, subround, low plasticity, gravel quartzite with some arkosic arenite, ~~and~~ diorite and granite, Dom lithology sand quartz with some rock frags and trace dark minerals, mica and K-spar, some iron staining and caliche throughout, no apparent bedding, moist, some root present
	Run 2 / 4.6	1.0	BH00175WC02 / .8			52% gravel 31% Sand 13% clay 4% silt	GC	2.0 / 3.0		Sandy Gravel with some clay - Dusky Yellowish brown (10YR 2/2), max size gravel 2" diameter, average ½" diameter, coarse to fine-grained sand, poorly graded, subround, low plasticity, gravel quartzite with some granite, Dom lithology sand quartz with some rock frags and trace dark minerals and mica, abundant caliche throughout, no apparent bedding, moist, some wood frags @ 2.0'
	Run 3 / 6.0	1.2	BH00176WC02 / BH00177WC02			64% Gravel 32% Sand 3% silt 1% clay	GW	4.0 / 5.8 / 5.7 / 6.0		Sandy Gravel - Moderate brown (5YR 4/4), max size gravel greater than 2" diameter, average 1" diameter, coarse to fine-grained sand, subangular to subround, well graded, low plasticity, gravel primarily quartzite with some granite, Dom lithology sand rock frags with abundant quartz and some dark minerals and trace mica, K-spar and pyrite, trace iron staining on grains, trace carbonaceous material from 12.0-12.8, some caliche from 4.8-7.1, no apparent bedding, moist,
	Run 4 / 8.0	1.3	.3					7 / .1 / .3		
	Run 5 / 10.0	0.6						8.0 / .4 / .6 / 9 / 10.0		

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS PLANT BOREHOLE LOG

FORM GT.1A

Borehole Number: 10291
Location - North: East:
Date: 12/6/91
Geologist: LUS/LAG
Drilling Equip.: CME 75

Surface Elevation:
Area: NE TRENCHES
Total Depth: 60.0
Company: EG&G
Project No.: 002RFI RI PHII
Sample Type: continuous core

EG&G LOGGING SUPERVISOR

APPROVAL ______________________ DATE ______________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDFORM ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 5	RUN 6 12.0	BH00178WC01	0.8				GW	11 12		Sandy Gravel
	RUN 7 14.0		0.8					13 14		
	RUN 8 16.0	BH00181WC02 .8	1.2					15 16		
BOX 2 of 5	RUN 9 18.0	BH00182WC02	1.1					17 18		Top Bedrock @ 18.0'
20.0	RUN 10 20.0	BH00183WC02 .8				56% Sand 40% Silt 4% Clay		19 20 21		Silty Sandstone - Pale olive (10Y 6/2), fine to very fine-grained sand well sorted, subangular to subround, ~20% porosity, argillaceous cement, moderately friable, Dom lithology sand clear quartz with some dark minerals, some limonite controlled by bedding planes, trace Mn staining throughout some sand clast from 18.8-19.0 clay layer from 18.9-19.0, clay layer from 20.4-20.0 with trace soft sediment deformation, trace horizontal bedding with some hammocky-cross stratification from 20.0-20.3

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number: 10291
Location - North:
East:
Date: 12/9/91
Geologist: D.A. D/EAG
Drilling Equip.: CME 75

Surface Elevation:
Area: N.E TRENCHES
Total Depth: 60.0
Company: EG&G
Sample Type: CORE

Project No.: OU2/RFI RI PH II

EG&G LOGGING SUPERVISOR

APPROVAL ______________________ DATE ______________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	SAMPLE DESCRIPTION
					0°					trace horizontal bedding with trace soft sediment deformation from 20.6-22, no apparent fractures, moist, unweathered.
Box 2	Run 11	1.7			0°			21	.7	
	22.0							22	.2	
	Run 12	2.0	BH00184WCU2		10°			23		10° bedding from 23.3-24.0 Some hummocky cross-stratification from 23.3-30.2
	24	.8						24	.8	band iron staining from 24.5-25.9
	Run 13	2.0	BH00185WCU2		10°			25		10° bedding from 24.8-25.3
	26.0							26	.8	
	Run 14	2.0	BH00186WCU2					27		
	28.0							28	.8	
	Run 15	1.9	BH00187WCU2					29	.2 .1	trace wood frags @29.1
	30.0									

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.
(2) Core breaks cannot be matched, accurage footage measurements not possible.

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number: /0291 | Surface Elevation:
Location - North: | East: | Area: N.E. TRENCHES
Date: 12/9/91 | Total Depth: 60.0
Geologist: D.A. DEHN / WAV | Company: EG&G | Project No.: 002/RFI RI/PH II
Drilling Equip.: CME 75 | Sample Type: Continuous Core

EG&G LOGGING SUPERVISOR

APPROVAL ______________________ DATE ______________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	SAMPLE DESCRIPTION
BOX 2 of 5 / 32.0	RUN 16 / 32.0	1.5	BH00188WCU2; BH00187WCU2	-	-			31, .3, 32		very thin clay and sand laminations with trace hummocky cross stratification from 30.2-32.4, trace iron nodules from 30.2-34.3, trace carbonaceous material controlled by bedding from 30.2-34.3.
BOX 3 of 5	RUN 17 / 34.0	2.0			10°			33, .8, 34		trace 10° bedding 33.0-33.5
	RUN 18 / 36.0	1.8	BH00189WCU2; BH00190WCU2			46% silt, 31% clay, 23% sand		.3, 35, .8, 36		Clayey Siltstone with some sand - olive gray (5Y 3/2) to dark yellowish orange (10YR 6/6), very fine-grained sand, well sorted, subangular, ~10% porosity, argillaceous cement, slightly to moderately friable, Dom lithology sand clear quartz with trace dark minerals, iron nodules and mica, some iron staining on grains, some limonite throughout, abundant limonite from 36.2-36.5, clay layers from 34.3-34.4 and laminations from 35.1-35.6, no apparent fractures, moist, some carbonaceous material @ 36.1, weathered.
	RUN 19 / 38.0	2.0				90% sand, 9% silt, 1% clay		.3, 37, .8, 38		Sandstone with some silt - Dusky yellow (5Y 6/4), Coarse to very fine-grained sand, poorly sorted, subround to round, ~30% porosity, silica with trace argillaceous cement, highly friable, Dom lithology sand clear quartz with some dark minerals and iron nodules, trace iron staining on grains, some limonite and trace clay clast throughout, massive, no apparent bedding or fractures, very moist to wet, weathered.
	RUN 20 / 40	2.0	BH00192WCU2	10-45°		63% clay, 21% sand, 16% silt; 56% sand		39, .8		Sandy Claystone with some silt - olive gray (5Y 3/2), fine to very fine-grained sand, well sorted, subangular to subround, ~10% porosity, argillaceous cement, slightly friable, Dom lithology sand clear quartz with trace dark minerals, trace limonite, no apparent bedding, some 10°-45° healed fractures with Fe from 38.4-38.8, wet, slightly weathered.

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number: 10291
Location - North:
East:
Date: 12/10/91
Geologist: S.A.S/LA
Drilling Equip.: CME-75

Surface Elevation:
Area: N.E. TRENCHES
Total Depth: 60.0
Company: EG&G
Sample Type: CORE
Project No.: OU2/RFI RI/PHII

EG&G LOGGING SUPERVISOR

APPROVAL ______________________ DATE ______________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG
BOX 3 of 5	RUN 21	2.0	BH00193WCU2			35% silt 5% clay		.7	
	42.0				0°-10°	45% silt 40% sand 15% clay		41	
.42.0	RUN 22	2.0				83% sand 15% silt 2% clay		42	
BOX 4 of 5					0°-10°	55% sand 34% silt 8% clay		43, .8	
	44.0					87% sand 11% silt 2% clay		44	
	RUN 23	2.0						45, .6	
	46.0		BH00194WCU2		15°, 10°	54% sand 36% silt 10% clay		.8, 46, 47	
	48.0							48	
	RUN 25	2.0				89% sand 10% silt 1% clay		49, .8	
	50								

SAMPLE DESCRIPTION

Silty Sandstone with some clay - Dusky yellow (5Y6/2) very fine-grained sand, well sorted, subangular, ~20% porosity, argillaceous cement moderately friable, Dom lithology sand clear quartz with trace dark minerals and iron nodules, some iron staining on grains, some limonite and trace clay clast throughout, no apparent bedding or fractures, very moist, weathered

Sandy Siltstone with some clay - grayish olive (10Y4/2) very fine-grained sand, well sorted, subangular to subround, ~15% porosity, argillaceous cement, slightly to moderately friable, Dom lithology sand clear quartz with trace dark minerals, trace iron staining on grains trace limonite throughout, hummocky cross-stratification with low angle bedding from 40.7-41.8, no apparent fractures, very moist, slightly ~~[illegible]~~ weathered.

Sandstone with some silt - Dusky yellow (5Y6/2), fine to very fine-grained sand, well sorted, subangular to subround, ~25% porosity, argillaceous and silica cement, highly friable, Dom lithology sand clear quartz with trace dark minerals and iron nodules, some limonite throughout, no apparent fractures or bedding, very moist, weathered.

Silty Sandstone with some clay - grayish olive (10Y4/2), very fine-grained sand, well sorted, subangular to subround ~20% porosity, argillaceous cement, moderately friable, Dom lithology sand clear quartz with trace dark minerals some limonite throughout no apparent bedding or fractures very moist.

Sandstone with some silt - dark yellowish orange (10YR6/6), fine to very fine-grained sand, well sorted, subround to round, ~25% porosity, ~~[illegible]~~ silica with trace argillaceous cement, highly friable, Dom lithology sand clear quartz with some dark minerals and trace iron nodules ~~[illegible]~~ limonite and trace clay clast throughout, trace low angle bedding from 43.0-43.8, some thin clay laminations from 44-44.6, 10° bedding controlling limonite from 44.6-45.6, no apparent fractures, very moist, weathered.

Silty Sandstone with some clay - light olive gray (5Y5/2), very fine-grained sand, well sorted, subangular to subround, ~20% porosity, argillaceous cement slightly to moderately friable, Dom lithology sand clear quartz with trace iron nodules, trace limonite throughout, 15° bedding from 45.6-45.8, trace cross bedding from 47.1-47.2, 10° bedding from 47.5-47.9, no apparent fractures, moist, weathered.

Sandstone - Dusky yellow (5Y6/2) fine to very fine grained sand, well sorted subangular to subround, ~25% porosity, silica cement, highly friable, Dom lithology sand clear quartz with trace dark minerals, trace iron staining on grains, some limonite throughout, abundant limonite from 49.0-49.3, no apparent fractures, moist, weathered

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number: 1029
Location - North:
East:
Date: 12/10/91
Geologist: J.A.D/LAB
Drilling Equip.: CME-75

Surface Elevation:
Area: N.E. TRENCHES
Total Depth: 60.0
Company: EG&G
Sample Type: CORE
Project No.: OU2/RFI RI/PHII

EG&G LOGGING SUPERVISOR

APPROVAL ______________________ DATE ______________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	SAMPLE DESCRIPTION
BOX 4 of 5	RUN 26 52.0	2.0			10°	48% Sand 37% clay 15% silt		51 52		Clayey Sandstone - olive gray (5Y 3/2), very fine grained sand, well sorted, subangular, ~15% porosity, argillaceous cement, slightly friable, Dom lithology sand clear quartz with some dark minerals, some iron staining on grains, some sand rip-up clast throughout, trace clay clast throughout, some limonite controlled by bedding planes, trace carbonaceous material, thin laminations of sand and clay with 10° bedding from ~~[illegible]~~ 50-52.7, some soft-sediment deformation throughout, wavy stratification from 52.7-54.0 no apparent fractures, moist, mottled appearance
53.0 Box 5 of 5	RUN 27 54.0	2.0						53		Sandstone with some silt - Dusky Yellow (5Y 6/4), fine to very fine-grained sand, well sorted, subangular to subround, ~25% porosity, silica cement, highly friable, Dom lithology sand clear quartz, some limonite throughout, no apparent bedding or fractures, moist.
	RUN 28 56.0	2.0	BH00195WCUZ 0 2 5 BH00196WCUZ			91% Sand 8% silt 1% clay 68% clay 29% silt 3% sand		54 55 56		Silty Claystone - dark gray (N3), very fine-grained sand, well sorted, subangular, ~5% porosity, argillaceous cement, non- to slightly friable, Dom lithology sand clear quartz with trace dark minerals, some limonite from 54.3-54.7, trace carbonaceous throughout, blocky - wavy stratification 54.3-57.2, no apparent fractures, moist, weathered from 54.3-54.7, unweathered 54.7-57.6
	RUN 29	2.0						57		
60.0	58.0 RUN 30 60.0	2.0	BH00197WCUZ			47% Sand 40% silt 13% clay		58 59		Silty Sandstone with some clay - dark gray (N3), fine to very fine-grained sand, well sorted, subangular to subround, ~15% porosity, slightly to moderately friable, argillaceous cement, Dom lithology sand clear quartz with some dark minerals trace carbonaceous material throughout, 10° bedding from 57.8-58.9, no apparent fractures, moist, unweathered. T.D. @ 60.0'

NOTES: General: USCS is modified for this log as follows:
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible.

LOG OF BOREHOLE

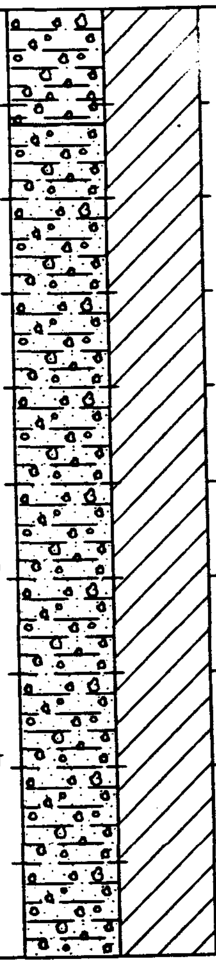
QA BY/DATE J.B. Burman 2-12-90
LOCATION Rocky Flats Plant; East Trenches Area
COORDINATES N36,823.58 E24,082.18 (RFP)
TOTAL DEPTH 221.3'

DRILLING COMPANY Boyles Brothers
DATE DRILLED October 17-18, 23-25,1989
DRILLING METHOD 0-75' Hollow Stem Auger, 75'-221.3' Rotary
LOGGED BY T. Lutherer, R. Morrow
GEOLOGIST

BOREHOLE/WELL NO. B217589
GROUND SURFACE ELEVATION 5952.9'
WATER LEVEL ENCOUNTERED 48.0'
STATIC N/A
DRILLER K. Parker, P. Bushkovski HELPER T. Merritt, J. Keim
DRILLING FLUID None 0.0-75.0'; Water 75'-221.3'
CHECKED BY J.B. Burman
SITE MANAGER

CEARP MANAGER

COMMENTS 5-5/8" Surface Casing set to 75.0' on October 18, 1989 by T.A. Lutherer.

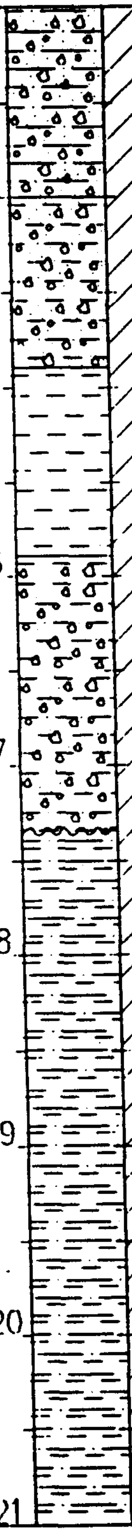
DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
0 1 2 3 4 5			**ROCKY FLATS ALLUVIUM** 0.0-2.0' SAMPLE. Recovered 2.0/2.0' = 100%. 0.0-0.6': GRAVELLY SILT: dusky brown (5 YR 2/2); 1-4 cm broken quartzose gravel, trace fine-grained sand; trace clay; organics; roots; stiff; dry. 0.6-2.0': GRAVELLY SILTY SAND: same as above; with fine to coarse-grained subrounded to subangular quartzose sand; roots; silt; occasionally grading to gravelly sandy clay; blackish red (5 R 2/2); low plasticity; dry. 2.0-4.0' SAMPLE. Recovered 1.0/2.0' = 50%. GRAVELLY SILTY SAND: same as 0.6-2.0'; with 2.0-2.4' moderate yellow brown (10 YR 5/4), 2.4-3-0' grayish orange pink (5 YR 7/2). 4.0-6.0' SAMPLE. Recovered 1.0/2.0' = 50%. GRAVELLY SILTY SAND: same as 2.0-4.0'; with 2-4 cm gravels to cobbles.	HNu Background: 0.0 OVA Background: 0.0 All readings on cuttings, in breathing zone, on core, and in augers: 0.0; unless otherwise noted below. TRIP BLANK SAMPLE TB101789B 0.0-0.2' SAMPLE (VOAs only) 5789BR0002 2.0' Reading in Auger HNu: 7 0.0-3.0' SAMPLE 5789BR0003 4.0-5.0' SAMPLE (VOAs only) 5789BR0406 4.0-7.2' SAMPLE 5789BR0408

17589apj

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
5 6 7 8 9 10 11 12 13			<u>6.0-8.0' SAMPLE.</u> Recovered 1.2/2.0' = 60%. GRAVELLY SILTY SAND: grading to gravelly clayey sand; same as 4.0-6.0'; with brownish black (5 YR 2/1); organics; fine- to coarse-grained subrounded to subangular quartzose sand, 2 cm gravels to cobbles; quartzose; non to low plasticity; dry. Note: 8.0-9.0': Drilled with center bit. No sample taken. <u>9.0-10.0' SAMPLE.</u> Recovered 1.0/2.0' = 50%. GRAVELLY SILTY SAND: grading to gravelly clayey sand; same as 6.0-8.0'; with light brown (5 YR 5/6) to moderate brown (5 YR 4/4). <u>10.0-12.0' SAMPLE.</u> Recovered 2.0/2.0' = 100%. 10.0-11.3': GRAVELLY CLAYEY SAND: grading to gravelly sandy clay; same as 9.0-10.0'; with trace to some silt; damp. 11.3-12.0': GRAVELLY SILTY SAND: same as 6.0-8.0'; with 2 cm gravels to cobbles; quartzose; stiff; <u>12.0-14.0' SAMPLE.</u> Recovered 1.0/2.0' = 50%. GRAVELLY SILTY SAND: same as 11.3-12.0'; with moderate brown (5 YR 4/4) and moderate orange pink (5 YR 8/4).	<u>9.0-10.0'</u> SAMPLE (VOAs only) 5789BR0910 <u>9.0-13.0'</u> SAMPLE 5789BR0913 <u>12.0-13.0'</u> SAMPLE (VOAs only) 5789BR1214 <u>13.0-17.3'</u> SAMPLE 5789BR1317

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED

Depth (ft): 13, 14, 15, 16, 17, 18, 19, 20, 21



LITHOLOGIC DESCRIPTION

<u>14.0-16.0' SAMPLE.</u>
Recovered 2.0/2.0' = 100%.
14.0-14.9': GRAVELLY CLAYEY SAND: same as 10.0-11.3'.
14.9-15.8': CLAY: yellow gray (5 Y 7/2) to grayish yellow (5 Y 8/4); trace gravels; trace sand; medium to high plasticity; damp to moist.
15.8-16.0': GRAVELLY CLAYEY SAND: same as 14.0-14.9'.

<u>16.0-18.0' SAMPLE.</u>
Recovered 2.0/2.0' = 100%.
16.0-17.3': GRAVELLY CLAYEY SAND: same as 15.8-16.0'.

<u>ARAPAHOE/LARAMIE FORMATION</u>

17.3-18.0': SILTY CLAYSTONE: moderate yellow (5 Y 7/6) to pale yellow brown (10 YR 6/2); nonstratified; traces of banding; medium to high plasticity; occasionally very silty; grading to clayey siltstone; damp.

<u>18.0-20.0' SAMPLE.</u>
Recovered 2.0/2.0' = 100%.
SILTY CLAYSTONE: same as 17.3-18.0'; with banding; mottled; blocky; stiff; damp.

<u>20.0-22.0' SAMPLE.</u>
Recovered 2.0/2.0' = 100%.
20.0-21.3': SILTY CLAYSTONE: same as 18.0-20.0'.
21.3-22.0': CLAYSTONE: with traces to some silt; high plasticity.

SAMPLES COLLECTED OR OTHER TESTS PERFORMED

<u>16.0-18.0'</u> SAMPLE
(VOAs only)
5789BR1618

<u>20.0-22.0'</u> SAMPLE
(VOAs only)
5789BR2022
5789BR2022D

<u>17.3-22.0'</u> SAMPLE
5789BR1722
5789BR1722D

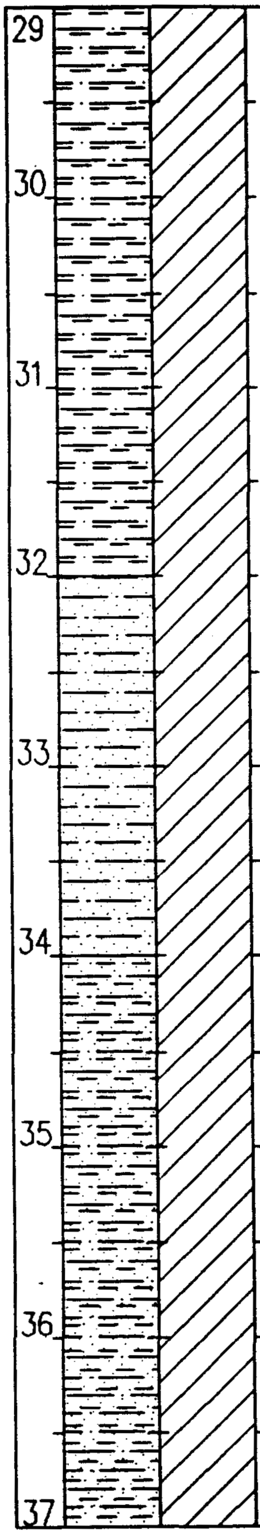
<u>FIELD BLANK</u> SAMPLE
5789BR1722FB

WELL NO. B217589 LOG OF BOREHOLE PAGE 4 OF 29

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
21			22.0-24.0′ SAMPLE. Recovered 2.0/2.0′ = 100%. SILTY CLAYSTONE: same as 18.0-20.0′; occasionally grading to claystone with some silt; with traces iron staining; moist.	
22			24.0-26.0′ SAMPLE. Recovered 2.0/2.0′ = 100%. SILTY CLAYSTONE: same as 22.0-24.0′; with moderate brown (5 YR 4/4) to moderate brown (5 YR 3/4) to olive gray (5 Y 4/1); iron banding; iron nodules.	
23			26.0-28.0′ SAMPLE. Recovered 2.0/2.0′ = 100%. SILTY CLAYSTONE: same as 24.0-26.0′; with light brownish gray (5 YR 6/1); traces very fine-grained sand.	
24			28.0-30.0′ SAMPLE. Recovered 2.0/2.0′ = 100%. SILTY CLAYSTONE: same as 26.0-28.0′; with silty sandy claystone occasionally grading to silty clayey sandstone; unconsolidated; very fine-grained quartzose sand.	
25				
26				
27				
28				
29				

17589d.pj

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED



30.0-32.0' SAMPLE.
Recovered 2.0/2.0' = 100%.
SILTY CLAYSTONE: same as 28.0-30.0'; with olive gray (5 Y 4/1); traces to some very fine-grained quartzose sand; well sorted; very hard; occasionally grading to silty sandy claystone and silty clayey sandstone with very fine- to occasionally medium-grained sand; damp.

32.0-34.0' SAMPLE.
Recovered 2.0/2.0' = 100%.
SILTY SANDSTONE: pale yellowish orange (10 YR 8/6) to light gray (N 7/0); predominantly very fine- to fine-grained quartzose sand; subangular to subrounded; moderately sorted; silty; low to medium plasticity; damp.

34.0-36.0' SAMPLE.
Recovered 2.0/2.0' = 100%.
SILTY CLAYEY SANDSTONE: same as 32.0-34.0'; with olive gray (5 Y 4/1); fine- to medium-, traces coarse-grained quartzose sand.

36.0-38.0' SAMPLE.
Recovered 2.0/2.0' = 100%.
SANDY SILTY CLAYSTONE: same as 34.0-36.0'; with predominantly very fine- to fine-grained sand; occasionally medium-grained sand; silty; medium to high plasticity; blocky; damp.

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
37–45			<u>38.0-40.0' SAMPLE.</u> Recovered 2.0/2.0' = 100%. 38.0-39.3': SANDY SILTY CLAYSTONE: same as 36.0-38.0'. 39.3-39.4': CLAYSTONE: gray (N 4/0); blocky; dense; high plasticity. 39.4-40.0': SILTY SANDY CLAYSTONE: same as 36.0-38.0'; with very fine- to fine-grained sand. <u>40.0-42.0' SAMPLE.</u> Recovered 2.0/2.0' = 100%. CLAYEY SILTY SANDSTONE; pale yellowish orange (10 YR 8/0) to light gray (N 7/0) and grayish yellow (5 Y 8/4); 2 mm banding; very fine- to fine-grained quartzose sand; subrounded to subangular; well to moderately sorted; trace to some silt; trace to some clay; medium to high plasticity; iron staining; 1-2 mm beds of silty claystone; dark gray (N 4/0); dense; hard; damp. <u>42.0-44.0' SAMPLE.</u> Recovered 2.0/2.0' = 100%. CLAYEY SILTY SANDSTONE: same as 40.0-42.0'; with 41.0-42.0' dark gray (N 3/0) to medium gray (N 5/0) and light gray (N 6/0). <u>44.0-46.0' SAMPLE.</u> Recovered 2.0/2.0' = 100%. CLAYEY SILTY SANDSTONE: same as 42.0-44.0'; 45.6-46.0: SANDY SILTY CLAYSTONE.	

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
45–53			**46.0-48.0' SAMPLE.** Recovered 2.0/2.0' = 100%. 46.0-47.5': CLAYEY SILTY SANDSTONE: same as 44.0-46.0'; with interbedded claystone; same as 39.3-39.4'. 47.5-48.0': SANDSTONE: dark yellowish orange (10 YR 6/6) to grayish orange (10 YR 7/4); nonstratified; fine- to medium-grained quartzose sand; subangular to subrounded, moderately sorted; trace silt; firm; moist. **48.0-50.0' SAMPLE.** Recovered 2.0/2.0' = 100%. CLAYEY SILTY SAND: dark yellowish orange (10 YR 6/6); predominantly fine- to medium-grained quartzose sand; locally interbedded with silty claystone; firm to stiff; wet. **50.0-52.0' SAMPLE.** Recovered 2.0/2.0' = 100%. 50.0-50.5': SILTY SAND: same as 48.0-50.0'; with light gray (N 7/0); traces to some clay; wet. 50.5-50.55': CLAYSTONE: light gray (N 7/0); silty; firm; high plasticity; wet. 50.55-52.0': SANDSTONE: dark yellowish orange (10 YR 6/6); same as 47.5-48.0'. **52.0-54.0' SAMPLE.** Recovered 2.0/2.0' = 100%. SANDSTONE: same as 50.55-52.0'; with light brown (5 YR 5/6); low coarse-grained quartzose sand; iron staining.	▽ 48.0'

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
53			54.0-55.0' SAMPLE. Recovered 0.0/1.0' = 0%. 55.0-56.0' SAMPLE. Recovered 0.0/1.0' = 0%.	
54			56.0-57.0' SAMPLE. Recovered 1.0/1.0' = 100%. SILTY SANDSTONE: grading at times to clayey sandstone; dark yellowish orange (10 YR 6/6) to medium gray (N 5/0); 2 mm banding; fine- to medium-grained quartzose sand; moderately sorted; iron staining, silty; traces clay; medium stiff; low plasticity; wet.	
55			57.0-59.0' SAMPLE. Recovered 1.7/2.0' = 85%. SILTY SANDY CLAYSTONE: same as 56.0-57.0'; with SILTY CLAYEY SANDSTONE stringers; medium plasticity; moist.	
56			59.0-61.0' SAMPLE. Recovered 1.8/2.0' = 90%. SILTY SANDY CLAYSTONE: same as 57.0-59.0'.	
57				
58				
59				
60				
61				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
61			**61.0-63.0' SAMPLE.** Recovered 2.0/2.0' = 100%. SILTY CLAYEY SANDSTONE: same as 56.0-57.0'; with medium light gray (N 6/0), medium gray (N 5/0) to medium dark gray (N 4/0).	
62			**63.0-65.0' SAMPLE.** Recovered 0.7/2.0' = 35%. SILTY SANDY CLAYSTONE: same as 57.0-59.0'.	
			65.0-67.0' SAMPLE. Recovered 2.0/2.0' = 100%. SILTY CLAYSTONE: same as 63.0-65.0'; with traces of fine- to medium-grained quartzose sand; lenticular.	
63			**67.0-69.0' SAMPLE.** Recovered 2.0/2.0' = 100%. SILTY CLAYSTONE: same as 65.0-67.0'; with traces to some sand; black (N 1/0) carbonaceous material.	
64				
65				
66				
67				
68				
69				

17589lpj

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
69			69.0-70.0' SAMPLE. Recovered 1.0/1.0' = 100%. SILTY CLAYSTONE: same as 67.0-69.0'; with traces sand.	
70			70.0-71.0' SAMPLE. Recovered 1.0/1.0' = 100%. SILTY CLAYSTONE: same as 69.0-70.0'; with traces sand.	
			71.0-72.0' SAMPLE. Recovered 1.0/1.0' = 100%. SILTY CLAYSTONE: same as 70.0-71.0'; with wet. 71.8-72.0': SILTY SANDY CLAYSTONE: fine- to medium-grained quartzose sand; subangular to subrounded.	
71			72.0-73.0' SAMPLE. Recovered 0.0/1.0' = 0%.	
72			73.0-74.0' SAMPLE. Recovered 1.0/1.0' = 100%. 73.0-73.4': SILTY CLAYEY SANDSTONE: same as 61.0-63.0'. 73.4-74.0': SILTY CLAYSTONE: same as 71.0-72.0'; with traces of sand.	
73			74.0-75.0' SAMPLE. Recovered 0.5/1.0' = 50%. SILTY SANDY CLAYSTONE: same as 73.0-74.0'; grading to silty clayey sandstone.	
			Note: 75.0-76.1': Drilled out cement.	
74			76.1-80.3' SAMPLE. Recovered 4.1/4.2' = 98%. RQD: 3.49/4.1' = 85%. CLAYSTONE: dark gray (N 3/0) to olive gray (5 Y 3/2); massive with olive black (5 Y 2/1) micro laminations; trace silt; moderately hard; no HCl reaction; moist.	
75				
76				
77				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
77			**80.3-84.3' SAMPLE.** Recovered 4.3/4.0' = 107.5%. RWD: 3.75/4.3' = 87%. SILTY CLAYSTONE: dark gray (N 3/0) to olive gray (5 Y 3/2) and olive black (5 Y 2/1); massive; 20% silt; trace grayish orange (10 YR 7/4) siderite nodules and laminations; trace organics; trace lignite to 2 mm; moderately hard; no HCl reactions; damp.	83.0': Reading on core: HNu: 1.2
78				
79			**84.3-88.3' SAMPLE.** Recovered 3.9/4.0' = 98%. RWD: 3.7/3.9' = 95%. 84.3-85.3': CLAYEY SILTSTONE: grayish olive green (5 GY 3/2) to grayish olive (10 Y 4/2); some silt; some carbonaceous micro laminations; slickensided. 85.3-88.3': SILTY SANDSTONE: medium gray (N 5/0) to medium dark gray (N 4/0); laminated; trace interbedded with sandy claystone; very fine- to fine-grained sand (2.5-3.5 phi); subangular; subrounded; carbonaceous and fossiliferous; some siderite laminations and nodules; very hard; damp.	
80				
81				
82				
83				
84				
85				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
85 86 87 88 89 90 91 92 93			88.3-92.3' SAMPLE. Recovered 3.9/4.0' = 98%. RQD: 3.75/3.9' = 97%. SANDY SILTSTONE: dark greenish gray (5 GY 4/1); laminations to 10 mm; olive gray (5 Y 4/1) sand stringers from 90.0' to 92.0'; very fine- to fine-grained, moderately sorted; subrounded to subangular; siderite stringers to 5 mm thick from 91.0 to 92.3'; some carbonaceous material; moderately hard; no HCl reactions; damp. 92.3-96.3;' SAMPLE. Recovered 3.25/4.0' = 81%. RQD: 2.55/3.25' = 78%. SILTY CLAYSTONE: greenish black (5 G 2/1) to dark gray (N 3/0); micro laminated; silt to 20%; yellowish gray (5 Y 7/2) to light olive brown (5Y 5/2) siderite nodules and stringers; trace slickensides to 80° orientation; increasing slickensides of various orientations with depth; claystone is slightly carbonaceous; moderately hard, some with low plasticity; no HCl reaction; fresh; moist to damp.	85.3-91.9' SAMPLE GEOTECHNICAL (Hydrometer Analysis) 5789BR8391 10% Sand 53% Silt 27% Clay

17588L

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
93			**96.3-100.3' SAMPLE.** Recovered 4.0/4.0' = 100%. RQD: 3.8/4.0' = 95%. SILTY CLAYSTONE: olive gray (5 Y 3/2) to dark gray (N 3/0); massive; silt to 20%; slickensides at various orientations including vertical; trace light olive brown siderite nodules (5 Y 5/6); trace carbonaceous plant material; moderately hard, no HCl reaction; damp.	
94			**100.3-104.3' SAMPLE.** Recovered 2.4/4.0' = 60%. RQD: 1.9/2.4' = 79%. CLAYSTONE: olive gray (5 Y 3/2) to medium dark gray (N 4/0); massive; blocky; some silt; moderately hard; some moderate to high plasticity; no HCl reaction; damp.	
95				
96				
97				
98				
99				
100				
101				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
101 102 103 104 105 106 107 108 109			104.3-107.3' SAMPLE. Recovered 2.9/3.0' = 97%. RQD: 2.2/2.9' = 76%. SILTY CLAYSTONE: olive black (5 Y 2/1) to grayish black (N 2/0); unstratified; silt to 35%; some carbonaceous material; moderately hard; no HCl reaction; moist to damp. 107.3-111.3' SAMPLE. Recovered 4.6/4.0' = 115%. RQD: 3.6/4.6' = 78%. 107.3-110.1': SILTY CLAYSTONE: same as 104.3-107.3'; increasing silt with depth. 110.1-111.3': SILTY CLAYSTONE: greenish black (5 GY 2/1) to dark gray (N 3/0); soft sediment deformation; trace carbonaceous laminations; slickensided at 45° orientation, silt to 35%; moderately hard to hard; no HCl reaction; damp.	107.3': Reading on Core: HNu: 0.8.

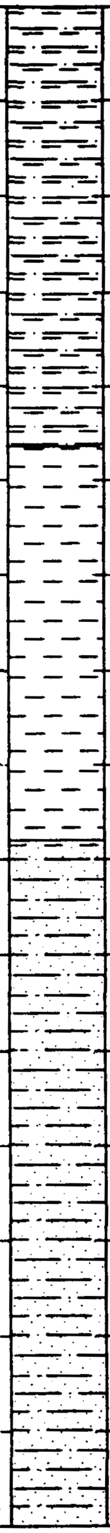
DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
109			**111.3-115.3' SAMPLE.** Recovered 4.0/4.0' = 100%. RQD: 3.75/4.0' = 94%. 111.3-114.2': SILTY CLAYSTONE: dark gray (N 3/0); massive; unlaminated; silt to 35%; slickensided at 70° orientation; trace carbonaceous material; moderately hard, no HCl reaction; damp. 114.2-115.3': SILTY SANDSTONE: medium gray (N 5/0); homogeneous; unlaminated; silt to 35%; very fine-grained sand; well sorted; subangular; quartzose; moderately hard to hard; no HCl reaction; damp. **115.3-119.3' SAMPLE.** Recovered 4.1/4.0' = 102.5%. RQD: 3.8/4.1' = 93%. 115.3-115.6': CLAYSTONE: medium gray (N 5/0); predominantly homogenous; trace laminations; trace silt; trace siderite; firm; no HCl reaction; moist. 115.6-119.3': SILTY CLAYSTONE AND CLAYEY SILTSTONE: dark gray (N 3/0); massive; blocky; silt from 35 to 35%; increasing silt with depth; trace dusky yellow (5 Y 6/4) siderite nodules at 116.0'; moderately hard to hard; no HCl reactions; damp.	
110				
111				
112				
113				
114				
115				
116				
117				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
117			**119.3-123.3' SAMPLE.** Recovered 3.2/4.0' = 80%. RQD: 3.2/3.2' = 100%. SILTY CLAYSTONE AND CLAYEY SILTSTONE: same as 115.6-119.3'; with dusky yellow (5 Y 6/4) siderite nodules.	
118			**123.3-127.3' SAMPLE.** Recovered 0.15/4.0' = 3%. RQD: 0%. SILTY CLAYSTONE AND CLAYEY SILTSTONE; same as 115.6-119.3'.	
119				
120				
121				
122				
123				
124				
125				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
125			**127.3-128.3' SAMPLE.** Recovered 1.6/1.0' = 160%. RQD: 0.6/1.6' = 38%. SILTY CLAYSTONE: dark gray (N 3/0) to olive black (5 Y 2/1); massive; blocky; slickensided to 20° orientation; silt to 30%; moderately hard; no HCl reaction; fresh; damp.	
126			**128.3-132.0' SAMPLE.** Recovered 3.7/3.7' = 100%. RQD: 1.85/3.7' = 50%. CLAYSTONE: medium dark gray (N 4/0); massive; no striations; blocky; some silt to 15%; moderate to high plasticity; no HCl reaction; fresh, moist to wet.	
127			**132.0-136.3' SAMPLE.** Recovered 1.2/4.3' = 28%. RQD: 0.45/1.2' = 38%. 132.0-135.5': CLAYSTONE: medium gray (N 5/0) to medium dark gray (N 4/0); massive; blocky; trace silt; soft; high plasticity; no HCl reaction; wet. 135.5-136.3': SILTY CLAYSTONE: olive black (5 Y 2/1); unstratified; blocky; silt to 35%, moderately hard; fresh; no HCl reaction; damp.	
128				
129				
130				
131				
132				
133				

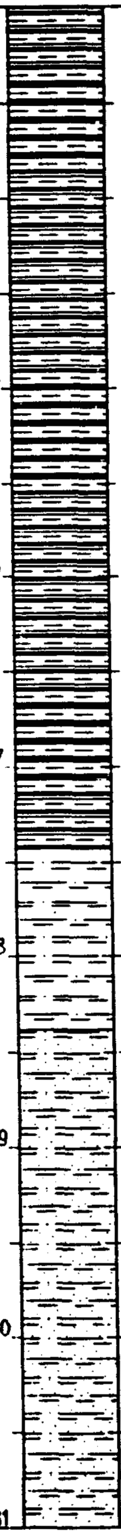
DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
133			**136.3-138.3' SAMPLE.** Recovered 3.3/2.0' = 165%. RQD: 0.7/3.3' = 21%. SILTY CLAYSTONE: same as 132.0-136.3'. **138.3-142.3' SAMPLE.** Recovered 3.0/4.0' = 75%. RQD: 0.5/3.0' = 16%. SILTY CLAYSTONE: dark gray (N 3/0); homogeneous; blocky to fissile; silt to 20%; predominantly low plasticity; trace highly plastic; no HCl reaction; fresh; damp.	
134				
135				
136				
137				
138				
139				
140				
141				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
141			142.3-146 3' SAMPLE. Recovered 0.0/4.0' = 0%. 146.3-147.3' SAMPLE. Recovered 1.6/1.0' = 160% RQD: 0.0/1.6' = 0%. CLAYEY SILTSTONE: dark gray (N 3/0); massive; blocky in part; clay to 35%; trace black (N 1/0) carbonaceous laminations; moderately hard; no HCl reactions; low plasticity; fresh; damp. 147.3-151.3' SAMPLE Recovered 0.0/4.0' = 0%.	
142				
143				
144				
145				
146				
147				
148				
149				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
149–157			**151.3-153.3′ SAMPLE.** Recovered 0.85/2.0′ = 42%. RQD: 0.0/0.85′ = 0%. CLAYSTONE: dark gray (N 3/0); massive; blocky in part; unstratified; trace to some silt; trace siderite nodules; moderate to high plasticity; no HCl reaction; fresh; damp. **153.3-155.3′ SAMPLE.** Recovered 4.7/2.0′ = 235%. RQD: 3.2/4.7′ = 68%. SANDY SILTSTONE: dark gray (N 3/0); massive; grades to silty sandstone with depth; no laminations or striations; trace clay; sand to 35-45%; very fine-grained ; well sorted; subangular; quartzose; well cemented; hard to very hard; no HCl reaction; fresh; damp. **155.3-159.3′ SAMPLE.** Recovered 3.7/4.0′ = 93% RQD: 3.7/3.7′ = 100%. SANDY SILTSTONE: medium dark gray (N 4/0) to dark gray (N 3/0); massive; no laminations; trace sand to 45%; clay trace to 10%; predominantly sand to [illegible] is very fine-grained; well sorted; [illegible] quartzose, well cemented; moderate to very hard; no HCl reaction; fresh; damp.	

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
157			**159.3-163.3' SAMPLE.** Recovered 2.35/4.0' = 58.5%. RQD: 0.0/4.0' = 0%. SILTY CLAYSTONE: dark gray (N 3/0) to grayish black (N 2/0); massive; no striations or laminations; blocky in part; silt to 25%; moderately hard to hard; low to moderate plasticity; no HCL reaction; fresh; damp.	
158				
159			**163.3-167.3' SAMPLE.** Recovered 4.3/4.0' = 108%. RQD: 3.65/4.3' = 85%. CLAYEY SILTSTONE: dark gray (N 3/0); mottled with medium dark gray (N 4/0) in part; 10-12 mm laminations in part; clay to 20%; some siderite nodules (15%) at 167.0'; trace siderite nodules throughout; hard; fresh; damp.	
160				
161				
162				
163				
164				
165				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
165			**167.3-171.3' SAMPLE.** Recovered 2.0/4.0' = 50%. RQD: 1.05/2.0' = 53%. CLAYSTONE: grayish black (N 2/0); massive; trace silt to 10%; some light gray (N 7/0) to yellowish gray (5 Y 7/2) siderite nodules and laminations to 30 mm; trace carbonaceous laminations to 2 mm; hard; no HCl reactions; fresh; non plastic; damp. **171.3-173.3' SAMPLE.** Recovered 3.75/2.0' = 185%. RQD: 3.05/3.75' = 81%. CARBONACEOUS CLAYSTONE: dark gray (N 3/0); massive; trace silt; some yellowish gray (5 Y 7/2) siderite nodules and laminations; hard to very hard; no HCl reactions; fresh; damp.	
166				
167				
168				
169				
170				
171				
172				
173				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
173 174 175 176 177 178 179 180 181			**173.3-177.3' SAMPLE.** Recovered 0.4/4.0' = 10%. RQD: 0.0/0.4' = 0%. CARBONACEOUS CLAYSTONE: same as 171.3-173.3'; with trace carbonaceous material in core. **177.3-178.3' SAMPLE.** Recovered 2.35/1.0' = 235%. RQD: 0.4/2.35' = 17%. SILTY CLAYSTONE: grayish black (N 2/0); massive to blocky; silt to 30%; trace yellowish gray (5 Y 7/2) siderite nodules; trace carbonaceous streaks; moderately hard to hard; non plastic; no HCl reactions; damp. **178.3-182.3' SAMPLE.** Recovered 4.25/4.0' = 106%. RQD: 4.15/4.25' = 98%. CLAYEY SILTSTONE AND SILTY SANDSTONE: medium dark gray (N 4/0) to olive gray (5 Y 3/2); unlaminated; thinly interbedded with silty sandstone; clay to 20%; trace siderite nodules; very fine-grained sand; well sorted; subangular to subrounded; quartzose; well cemented; hard; no HCl reaction; fresh; damp.	

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
181			**182.3-186.3' SAMPLE.** Recovered 4.47/4.0' = 112%. RQD: 4.47/4.47' = 100%. CLAYEY SANDY SILTSTONE AND SILTY SANDSTONE: dark gray (N 3/0) to medium dark gray (N 4/0); interbedded; clay to 20%; sand to 20%; trace slickensides to 70° orientation; silty sandstone has silt to 20%; very fine- to fine-grained sand; well sorted; subangular to subrounded; quartzose; very hard; fresh; damp. **186.3-190.3' SAMPLE.** Recovered 4.0/4.0' = 100%. RQD: 3.87/4.0' = 97%. SILTY SANDSTONE AND SANDY SILTSTONE: interbedded; some clay; some siderite nodules and laminations; trace to some carbonaceous material and fossils; very fine-grained sand; well sorted; subangular to subrounded; quartzose; well cemented; very to extremely hard; weak HCl reaction; fresh; grades to predominantly siltstone with depth; damp.	
182				
183				
184				
185				
186				
187				
188				
189				

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
189			190.3-194.3' SAMPLE. Recovered 3.8/4.0' = 95%. RQD: 3.75/3.8' = 99%. SANDY SILTSTONE: dark gray (N 3/0) to medium dark gray (N 4/0); some soft sediment deformation; laminated with carbonaceous material and siderite; trace slickensides to 70° orientation; trace to some yellowish gray (5 Y 7/2) siderite nodules; trace carbonaceous plant material; trace clay to 10%; very fine-grained sand; well sorted; subrounded; well cemented; very to extremely hard; no HCl reaction; damp. 194.3-198.3' SAMPLE. Recovered 4.0/4.0' = 100%. RQD: 3.75/4.0' = 94%. SILTY SANDSTONE: medium dark gray (N 4/0) and olive gray (5 Y 4/1) some carbonaceous laminations; trace slickensides; some fossils and carbonaceous plant material; silt to 35%; some clay to 18%; very fine-grained sand; trace fine-grained; well sorted; subangular to subrounded; quartzose; very to extremely hard; no HCl reactions; damp.	
190				
191				
192				
193				
194				
195				
196				
197				

17589y.pj

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
197				
198				
199				
200				
201				
202				
203				
204				
205				

198.3-202.3' SAMPLE.
Recovered 4.05/4.0' = 101%.
RQD: 3.9/4.05' = 96%.
SANDY SILTSTONE AND SILTY SANDSTONE: medium dark gray (N 4/0) and dark gray (N 3/0); thinly interbedded; soft sediment deformations; trace siderite and carbonaceous laminations; trace siderite fracture fill; trace to some carbonaceous plant material; very fine-grained sand; well sorted; subrounded; quartzose; well cemented; very hard; no HCl reactions; damp.

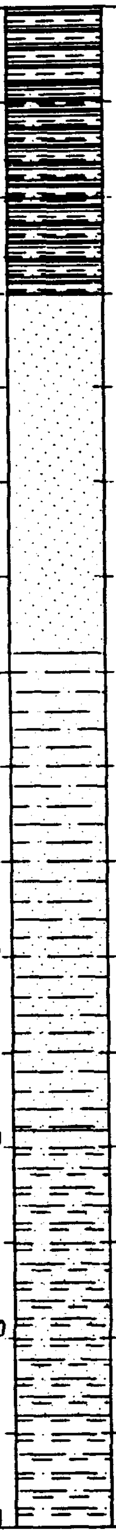
202.3-206.3' SAMPLE.
Recovered 4.2/4.0' = 105%.
RQD: 3.3/4.2' = 79%.
SILTY CLAYSTONE: medium dark gray (N 4/0) to dark gray (N 3/0); trace brownish black (5 YR 2/1); massive; trace fractures; some slickensides at various orientations; silt to 20%; trace lignite in fractures; trace carbonaceous material; trace siderite nodules; moderately hard; low to moderate plasticity; no HCl reactions; damp.

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
205			**206.3-210.3' SAMPLE.** Recovered 2.85/4.0' = 71%. RQD: 2.35/2.85' = 82%. CLAYSTONE: dark gray (N 3/0); massive; blocky; trace carbonaceous plant material; trace silt; trace slickensides at 0° orientation; soft, no HCl reactions; moist.	
206			**210.3-213.3' SAMPLE.** Recovered 2.65/3.0' = 88%. RQD: 1.95/2.65' = 74%. 210.3-212.5': CLAYSTONE: dark gray (N 3/0) to olive gray (5 Y 4/1); massive; blocky; trace silt to 5%; moderately hard; no HCl reaction; damp. 212.5-213.3': CARBONACEOUS CLAYSTONE: brownish black (5 YR 2/1); blocky; no laminations; some lignite; soft; brittle; no HCl reactions; damp.	
207				
208				
209				
210				
211				
212				
213				

LOG OF BOREHOLE

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED

213
214
215
216
217
218
219
220
221



213.3-216.3' SAMPLE.
Recovered 4.45/3.0' = 148%.
RQD: 3.87/4.45' = 87%.
213.3-214.5': CARBONACEOUS SILTY, CLAYSTONE: same as 212.5-213.3' with silt to 20%.
214.5-216.3': SANDSTONE: dark greenish gray (5 G 4/1) massive; trace silt; trace carbonaceous material; some clay to 15%; clay decreases with depth; very fine- to fine-grained sand; well sorted; subrounded; glauconitic; very hard; no HCl location; damp to moist.

216.3-220.3' SAMPLE.
Recovered 2.75/4.0' = 69%.
RQD: 2.75/2.75' = 100%.
216.3-218.8': SILTY SANDSTONE: greenish gray (5 G 6/1) to dark greenish gray (5 G 4/1); massive; soft sediment deformation structures; silt to 25%; some clay to 15%; trace carbonaceous plant material; trace siderite nodules at 218.5'; very fine- to fine-grained sand; well sorted; subrounded; quartzose; very hard; no HCl reactions.
218.8-220.3': SILTY SANDY CLAYSTONE: dark greenish gra[illegible] massive; silt to 20%; sand to 25%; very [illegible] fine grained sand; hard; no HCl reactions; damp.

220.3-221.3' SAMPLE.
Recovered 1.95/1.0' = 195%.
RQD: 1.1/1.95' = 56%.
SILTY CLAYSTONE: dark gray (N 3/0) to greenish black (5 GY 2/1); massive; trace pale yellowish orange (10 YR 8/6) siderite nodules; silt to 20%; trace carbonaceous material; some sand; very fine-grained sand; poorly sorted; subrounded; quartzose moderately hard to hard; no HCl reaction; damp.

WELL NO. B217589

LOG OF BOREHOLE

DEPTH (FT)	GRAPHIC LOG	SAMPLE TYPE	LITHOLOGIC DESCRIPTION	SAMPLES COLLECTED OR OTHER TESTS PERFORMED
221				
			TOTAL DEPTH = 221.3'	
222				
223				
224				
225				
226				
227				
228				
229				

APPENDIX D

QUALITY ASSURANCE ADDENDUM

Approved by:

_________________________ __/__/__ Director, Environmental Science & Engineering

_________________________ __/__/__ Project Manager

QUALITY ASSURANCE ADDENDUM

This Appendix consists of the Quality Assurance Addendum (QAA) for the Pilot Test Plan for Soil Vapor Extraction (SVE) Technology Subsurface Interim Measures Interim Remedial Action for the East Trenches Area (Operable Unit No. 2). This QAA supplements the "Rocky Flats Plant Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities" (QAPjP). This QAA establishes the site-specific Quality Assurance (QA) controls applicable to the investigation activities described in the ISV Technology Pilot Test Plan.

The previous SVE Pilot Test Plan described the performance specifications for design and construction of the SVE pilot system that will be tested in the alluvium at a site near IHSS No. 111.1, also known as Trench T-4, which is located within the boundary of Operable Unit No. 2 (OU2). This Pilot Test Plan is part of the Subsurface Interim Measures/Interim Remedial Action (IM/IRA) Plan for the removal of volatile organic compound (VOC) contamination from areas within OU2. SVE offers an alternative to conventional excavation, treatment, and disposal approach for remediation of soils contaminated with VOCs. SVE removes VOCs from the subsurface by drawing air through vadose zone strata pore spaces to extraction vents connected to a blower system that draws the VOC laden air to the surface where it is treated prior to discharge to the atmosphere. Preliminary results from the Phase II RFI/RI at OU2 indicate the presence of VOCs that are amenable to treatment by SVE (i.e., relatively low molecular weight compounds with Henry's law constants greater than 0.01). Preliminary site characterization results for the East Trenches Area were discussed in Section 2.1 of the SVE Pilot Test Plan.

D.1 ORGANIZATION AND RESPONSIBILITIES

The overall organization of EG&G Rocky Flats and the Environmental Restoration (ER) Management Organization responsible for implementing the ER Program activities at the DOE Rocky Flats Plant (RFP) is presented in Section 1.0 of the QAPjP. Functional responsibilities are also described in Section 1.0 of the (QAPjP).

The project-specific organization chart for the SVE Pilot Test at Trench T-4 will be prepared when the project subcontractors are identified.

D.2 QUALITY ASSURANCE PROGRAM

The QAPjP was written to address QA controls and requirements for implementing ER Program activities, as required by the RFP Interagency Agreement (IAG). The content of the QAPjP was driven by Department of Energy (DOE) Order 5400.1, the RFP QA Manual (RF QAM), and the IAG. DOE 5400.1 and the RF QAM both require a QA program to be implemented based on American Society of Mechanical Engineers (ASME) NQA-1, "Quality Assurance Requirements for Nuclear Facilities." The IAG specifies development of a QAPjP in accordance with the Environmental Protection Agency (EPA) QAMS-005/80, "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans." The 18-element format of NQA-1 was selected as the basis for both the QAPjP and subsequent QAAs with the applicable elements of QAMS-005/80 incorporated where appropriate. Figure 2-1 of Section 2.0 of the QAPjP illustrates where the 16 QA elements of QAMS-005/80 are integrated into the QAPjP and also into this QAA. Section 2.0 of the QAPjP also identifies other DOE Orders and QA requirements documents to which the QAPjP and this QAA are responsive.

The controls and requirements addressed in the QAPjP are applicable to SVE pilot testing activities, unless specified otherwise in this QAA. Where site-wide actions are applicable to SVE activities, the applicable section of the QAPjP is referenced in this QAA. This QAA addresses additional and site/project-specific QA controls and requirements that are applicable to the SVE pilot testing activities to be conducted at Trench T-4 that may not have been addressed on a site-wide basis in the QAPjP. Many of the QA requirements specific to the SVE pilot testing are addressed in the SVE Technology Pilot Test Plan and are referenced in this QAA.

D.2.1 Training

The minimum personnel qualification and training requirements that are applicable to EG&G and subcontractor staff for RFP ER Program activities are addressed in Section 2.0 of the QAPjP.
All EG&G and subcontractor staff working on SVE Pilot Test Plan for the East Trenches Area shall be trained in the EG&G Rocky Flats EM Operating Procedures, SVE Operational Procedures, and laboratory analytical procedures that are applicable to their assigned tasks. In addition to procedures training, EG&G and subcontractor personnel shall receive training on the requirements of the QAPjP and the IVS Technology Pilot Test Plan for the East Trenches Area (including this QAA). This training must be recorded, with verifiable documentation of training submitted to the EG&G Project Manager prior to implementing the SVE pilot testing activities described in the SVE Pilot Test Plan. EG&G and subcontractor personnel shall also be qualified to perform the tasks they have been assigned. Personnel qualifications must be documented, with documentation of qualifications verified by the EG&G Project Manager in accordance with EM administrative procedure 3-21000-ADM-02.02, Personnel Qualifications.

D.2.2 Quality Assurance Reports to Management

A QA summary report will be prepared annually or at the conclusion of the SVE Pilot Test Plan activities (whichever is more frequent) by the EG&G QA Manager. This report will include a summary of field operation and sampling oversight inspections, laboratory assessments, surveillance, and a report on data verification/validation results.

D.3 DESIGN CONTROL AND CONTROL OF SCIENTIFIC INVESTIGATIONS

D.3.1 Design Control

The SVE Pilot Test Plan for the East Trenches Area describes the general design considerations for implementing the SVE technology, outlines construction specification and performance requirements for the pilot SVE system (including vapor extraction vents, air injection vents, ground-water extraction wells, pressure monitoring probes, and vapor manifolds), summarizes site preparations for system installation, describes construction specifications and performance requirements for the vapor extraction unit, and summarizes the pilot system test operations. As such, the SVE Pilot Test Plan is considered the environmental investigation control plan for SVE technology testing at Trench T-4.

D.3.2 Data Quality Objectives

The development of Data Quality Objectives (DQOs) for the SVE technology testing at Trench T-4 was presented in Section 2.3 of the Pilot Test Plan. Data quality is typically measured in terms of precision, accuracy, representativeness, comparability, and completeness (also referred to as PARCC parameters). Precision, accuracy, and completeness are quantitative measures of data quality, while representativeness and comparability are qualitative statements that express the degree to which sample data represent actual conditions and describe the confidence of one data set to another. These parameters are defined in Appendix A of the QAPjP. Environmental samples to be collected and analyzed to provide measurement data associated with the SVE treatment system include pre-testing subsurface soil samples and air samples from the vapor extraction unit. Objectives measures for precision, accuracy, and completeness for vapor extraction unit air sample analyses were established in Section 2.3 of the SVE Test Plan.

Soil samples will be collected from the borings advanced for the installation of the pilot unit wells. These soil samples will be analyzed to provide information on VOC and radionuclide contaminant concentrations of the subsurface soils at the wells. Analytical methodology yielding Level IV data will be used for analysis of the soil samples (i.e., analytical protocols that are equivalent to EPA Contract Laboratory Program methods and procedures). The objectives for precision and accuracy for the analytes of interest will be as specified in Appendix B of the QAPjP (i.e., method-specific historical objectives for precision and accuracy). The objective for completeness for soil sample laboratory analyses is 90%.

D.3.3 Sampling Locations and Sampling Procedures

The SVE system consists of the following components:

- 1 alluvium extraction vent
- 1 alluvium forced air injection vent

- 1 sandstone extraction vent and ground-water extraction well
- 1 sandstone forced air injection vent and ground-water extraction well
- 3 alluvium pressure monitoring probes
- 2 sandstone pressure monitoring probes, and
- 1 vapor extraction unit

The extraction and injection vents and pressure monitoring (PM) probes will be installed in boreholes drilled with a hollow stem auger, according to EM Operating Procedures 5-21000-OPS-GT.2, Drilling and Sampling Using Hollow-Stem Auger Techniques. Hole depth and diameter specifications were established in Section 4 of the SVE Test Plan. Undisturbed soil cores will be collected continuously during drilling. Soil cores will be described according to EM Operating Procedure 5-21000-OPS-GT.1, Logging Alluvial and Bedrock Material. Soil core samples collected at 5, 10, and 15 feet will be collected according to OPS-GT.2, composited, and submitted to a laboratory for radionuclide analyses. The three soil core samples collected from the vapor extraction wells that display the highest organic vapor readings (as obtained according to 5-21000-OPS-FO.15, Use of PIDs and FIDs) will be forwarded to an off-site analytical laboratory for VOC analyses.

Air samples will be collected from three sample ports installed in the vapor extraction unit. The vapor extraction unit is described in Section 6 of the SVE Pilot Test Plan and the sample port locations are described in Section 6.7.7. Samples will be collected according to a sampling procedure to be developed following EPA Standard Test Method 18.

Additional EM Operating Procedures and to be developed SVE Vapor Extraction Unit Operational procedures that are applicable to the SVE pilot testing described in the SVE Pilot Test Plan are listed in Table D-1.

D.3.4 Analytical Procedures

VOCs in soil samples will be quantified according to EPA analytical method 8240. Soil samples will be analyzed for radionuclide activity levels according to methods specified in Part B of the EG&G General Radiochemistry and Routine Analytical Services Protocol (GRRASP). All laboratory analyses will adhere to procedures specified in Parts A and B of the GRRASP.

TABLE D-1
EM Operating Procedures and ISV Activities For Which They Are Applicable

EM Operating Procedures		Drilling for Vent and PM Probe Installation	Subsurface Soil Sampling	Groundwater Extraction Well Installation	Air Flow Modeling	Vapor extraction Unit Sampling	On-Site Model Laboratory
FO.01	Air Monitoring & Dust Control	●		●			
FO.02	Transmittal of QA Records		●		●	●	●
FO.03	General Equipment Decon.		●			●	
FO.04	Heavy Equipment Decon.	●		●			
FO.05	Handling of Purge and Development Water			●			
FO.06	Handling PPE	●	●	●		●	●
FO.07	Handling of Decon. Water & Wash Water	●	●	●			
FO.08	Handling of Drilling Fluids and Cuttings	●		●			
FO.10	Receiving, Labeling, and Handling Environmental Containers	●		●			
FO.11	Field Communications	●	●	●	●	●	
FO.12	Decon. Facility Operations	●		●			
FO.13	Containerizing, Preserving, Handling & Shipping Samples		●			●	●
FO.15	PID's and FID's		●				
FO.18	Environmental Sample Radioactivity Content Screening		●				
FO.19	Base Laboratory Work						●
GT.02	Drilling & Sampling Using Hollow Stem Auger Techniques	●	●	●			
GT.05	Plugging and Abandonment of Boreholes	●		●			
GW.02	Well Development			●			
TBD	Compositing Soil Samples		●				
TBD	Air Permeability Measurement					●	
TBD	Static Pressure Monitoring[1]					●	
TBD	Flow Rate Measurements[1]					●	
TBD	Air Flow Temperature[1]					●	
TBD	Air Flow Moisture[1]					●	
TBD	Subsurface Static Air Pressure					●	
TBD	Extraction Air Sampling[2]					●	●
TBD	Handling of Spent Granular Activated Carbon					●	

TBD = To Be Developed (i.e., SOP, written instruction, or scientific notebook).
[1] Source for these procecdures is EPA Source Method 2
[2] Source for this procedure is EPA Standard Test Method 18

R37085.PJ-010493

Data will be collected during the test runs and operation of the vapor extraction unit according to data collection procedures described in Section 7.4 of the SVE Pilot Test Plan. Air samples collected from the three air sample collection ports will be analyzed using an on-site portable gas chromatograph. In addition to installation of HEPA filters in the vapor extraction unit, an in-line, real-time alpha radiation monitor will be installed and connected to an alarm/system shutdown.

D.3.5 Equipment Decontamination

Sampling equipment that is used at more than one location shall be decontaminated between sampling locations in accordance with OPS-FO.03, General Equipment Decontamination. Other equipment (e.g., truck mounted auger) potentially contaminated during drilling and/or sampling shall be decontaminated as specified in OPS-FO.04, Heavy Equipment Decontamination.

D.3.6 Quality Control

Field sampling quality control will consist of: collection of field duplicate samples (for both air and soil analyses) at the rate of 1 per 20 samples (or for soil samples, at least one duplicate sample will be collected for analysis); replicate analysis of 1 in 20 air samples; and preparation and analysis of an equipment rinsate blank for every 20 soil samples collected (or at least one rinsate blank if 20 soil samples are not collected). Notwithstanding the QA sample schedule just presented, the number of field duplicates and replicates that will be collected will be limited to one each per day. Analytical laboratory QC for soil sample analyses shall be as specified in the GRRASP. A laboratory control sample shall be analyzed at the rate of 1 in 10 air samples.

D.3.7 Quality Assurance Monitoring

To assure the overall quality of the soil and air sampling and analysis activities associated with the SVE pilot testing at Trench T-4, field oversight inspections will be conducted during sampling and analysis activities.

D.3.8 Data Reduction, Validation, and Reporting

Data evaluation and reporting requirements for field and laboratory data are discussed in Section 8 of the SVE Pilot Test Plan.

D.4 PROCUREMENT DOCUMENT CONTROL

Procurement documents for items and services, including services for conducting field sampling and analysis, shall be prepared, handled, and controlled in accordance with the requirements and methods specified in Section 4.0 of the QAPjP.

D.5 INSTRUCTIONS, PROCEDURES, AND DRAWINGS

The SVE Pilot Test Plan for the East Trenches Area describes the field sampling, operational testing and monitoring, and analyses activities to be performed. The SVE Pilot Test Plan will be reviewed and approved in accordance with the requirements for instructions, procedures, and drawings outlined in Section 5.0 of the QAPjP.

Existing EM Operating Procedures and vapor extraction unit operational monitoring and sampling procedures are identified in Table D-1. Vapor extraction operational monitoring procedures identified as "TBD," and any other, quality-affecting procedures proposed for use but not identified in Table D-1 will be developed and approved as required by Section 5.0 of the QAPjP prior to performing the affected activity.

Changes and variances to approved operating procedures and the SVE Pilot Test Plan shall be documented through preparation of Document Change Notices (DCNs), which will be prepared, reviewed, and approved in accordance with requirements specified in Section 5.0 of the QAPjP.

In addition to the general specifications for the vapor extraction unit described in Section 6.2 of the SVE Pilot Test Plan, design submittals for the vapor extraction unit will be prepared and submitted to the EG&G Project Manager in accordance with Section 5 of the QAPjP. The submittals shall include:

- Manufacturer's drawing for each major component

- Detailed construction drawings
- Operating and maintenance manuals for major components and equipment
- Operating and Maintenance manual for the full system

D.6 DOCUMENT CONTROL

The following documents will be controlled in accordance with Section 6.0 of the QAPjP:

- Pilot Test Plan for In Situ Volatilization Technology for the Subsurface Interim Measures/Interim Remedial Action at the East Trenches Area (Operable Unit 2), including appendices.

- "Rocky Flats Plant Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities" (QAPjP)

- EM Operating Procedures and Vapor Extraction Unit Operational procedures (all operating procedures specified in the SVE Pilot Test Plan and this QAA).

D.7 CONTROL OF PURCHASED ITEMS AND SERVICES

Subcontractors that provide services to support the SVE pilot testing program activities will be selected and evaluated as outlined in Section 7.0 of the QAPjP. This includes pre-award evaluation/audit of proposed subcontractors as well as periodic assessment of the acceptability of contractor performance during the program. Any items or materials that are purchased for use during the pre-test sampling and SVE system installation, testing, and operation that have the ability to affect the quality of the data should be inspected upon receipt.

D.8 IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES, AND DATA

Soil and air samples shall be identified and handled, containerized, shipped, and stored in accordance with EM Operating Procedure 5-21000-OPS-FO.13, Containerizing, Preserving, Handling, and Shipping of Samples, and Sections 4.8 and 7.4 of the SVE Pilot Test Plan.

Sample identification and chain-of-custody will be maintained through the application of OPS-FO.13 and Section 8.0 of the QAPjP.

D.9 CONTROL OF PROCESSES

The overall processes of collecting and analyzing samples require control. The processes are controlled by adhering to the SVE Pilot Test Plan and the sampling and analytical procedures referenced.

The Vapor extraction unit process of the SVE system is described in Section 6 of the SVE Pilot Test Plan, including equipment and performance specifications. Any deviations from performance specifications identified in Section 6 of the SVE Pilot Test Plan must be documented per Section 15 of the QAPjP and EM Administrative Procedure 3-21000-ADM-15.01, Control of Nonconforming Items and Activities. Section 6 of the SVE Pilot Test Plan also includes a description of the process monitoring and control instrumentation of the vapor extraction unit.

D.10 INSPECTION

Following installation of the SVE system and connection of the aboveground equipment, a system shakedown inspection shall be conducted according to the requirements of Section 10.0 of the QAPjP. The system shakedown inspection will include the items and equipment identified in Section 7.2.1 of the SVE Pilot Test Plan. The system shakedown inspection shall be documented on an Inspection checklist developed specifically for this inspection and shall be conducted prior to the system startup test runs.

D.11 TEST CONTROL

A series of nine startup system tests shall be conducted of the SVE system. These tests are designed to determine the range of operating conditions that can be achieved by various system configurations, and to select the optimal operating conditions for sustained operations of the SVE system. The startup tests are described in Section 7.2.2 and summarized in Table 7-1 of the SVE Pilot Test Plan. The operational parameters and schedule of measurements to be taken during each of the startup tests are identified in Table 7-2 through 7-5 of the SVE Pilot Test Plan.

D.12 CONTROL OF MEASURING AND TEST EQUIPMENT (M&TE)

The GC used to analyze air samples should have a file that contains:

- Specific model and instrument serial number
- Operating instructions
- Routine preventative maintenance procedures, including a list of critical spare parts to be provided or available in the field
- Calibration methods, frequency, and description of the calibration solutions
- Standardization procedures (traceability to nationally recognized standards)

D.13 HANDLING, STORAGE, AND SHIPPING

Samples shall be packaged, transported, and stored in accordance with EM Operating Procedure 5-21000-OPS-FO.13.

D.14 STATUS OF INSPECTION, TEST, AND OPERATIONS

The status of the system shakedown inspection, the system startup tests, and sustained operations shall be documented according to the requirements of Section 14.0 of the QAPjP and Section 8 of the SVE Pilot Test Plan.

D.15 CONTROL OF NONCONFORMANCES

The requirements for the identification, control, evaluation, and disposition of nonconforming items, samples, and data will be implemented as specified in Section 15.0 of the QAPjP. Nonconformances identified by the implementing contractor(s) shall be submitted to EG&G for processing as outlined in the QAPjP and EM Administrative Procedure 3-21000-ADM-15.01.

D.16 CORRECTIVE ACTION

The requirements for the identification, documentation, and verification of corrective actions for conditions adverse to quality will be implemented as outlined in Section 16.0 of the QAPjP. Conditions adverse to quality identified by the implementing contractor shall be documented and submitted to EG&G for processing as outlined in the QAPjP.

D.17 QUALITY ASSURANCE RECORDS

Field QA records will be controlled in accordance with OPS-FO.02, Field Document Control. QA records to be generated during pre-test sampling and SVE system installation, inspection, testing, and operations are identified in referenced operating procedures and Section 8 of the IVS Test Plan.

D.18 QUALITY VERIFICATION

The requirements for the verification of quality shall be implemented as specified previously in Section D.3.7 of this Appendix.

A Readiness Review shall be conducted by the QAPM prior to implementing the field sampling, inspection, testing, and operating activities described in ;the SVE Pilot Test Plan. The readiness review will determine if all activity prerequisites have been met that are required to begin work. The applicable requirements of the QAPjP, the IVS Pilot Test Plan, and this QAA will be addressed.

D.19 SOFTWARE CONTROL

The requirements for the control of software are not applicable to the SVE testing activities to be performed at Trench T-4.

APPENDIX E

DESIGN CALCULATIONS

CLIENT/SUBJECT ______ W.O. NO. ______

TASK DESCRIPTION ______ TASK NO. ______

PREPARED BY ______ DEPT ______ DATE ______

MATH CHECK BY ______ DEPT ______ DATE ______

METHOD REV. BY ______ DEPT ______ DATE ______

APPROVED BY ______ DEPT ______ DATE ______

BLOWER SIZING CALCULATIONS

NEGATIVE PRESSURE PERFORMANCE: The blower performance required for the 3 test sites should meet the following conditions:

1. Be able to apply enough pressure to adequately determine the applicability of ISV. If the pilot test fails, it should be relatively clear that more negative pressu would not have made a difference.

2. Provide enough vaccum to adequatel demonstrate the effect of pressure on the alluvial materials. These mat'ls will require less pressure, bu low absolute pressures should also be evaluat if possible.

3. Have reasonable capital and O&M costs. P-D blowers offer this advantage. Although vacuum pumps offer lower pressure performance, high capital & O&M costs are associated. Vaccum pumps at sufficient air flow rates are impractile for a mobile unit.

A gauge pressure of 14 - 15" Hg should meet the above criteria

CLIENT/SUBJECT ______ W.O. NO. ______
TASK DESCRIPTION ______ TASK NO. ______
PREPARED BY ______ DEPT ______ DATE ______
MATH CHECK BY ______ DEPT ______ DATE ______
METHOD REV. BY ______ DEPT ______ DATE ______
APPROVED BY ______
DEPT ______ DATE ______

FLOW RATE PERFORMANCE:

ASSUMPTIONS:

1. The alluvium will provide the greatest flow rate of all formations
2. The approximate radius of influence in the alluvium will be 20 to 40 ft.
3. The permeability of the alluvium is approx. darcy (medium to coarse sand) 10 - 50 darcies
4. Sufficient air flow is achieved at 3" Hg in the alluvium.

Assuming steady-state radial flow distribution

$10 < Q/H < 25$ scfm/ft ; use 15 scfm/ft* (Johnson, 1988)

Based on the IRAP, the 903 Pad will have the largest treatmen interval in the alluvium ± 35 ft.

$$Q = (35\text{ft.})(15\text{ scfm/ft}) = 525\text{ scfm @ } 3''\text{Hg}$$

$$Q_{acfm} = (525\text{ scfm})\left(\frac{29.9}{29.9-3}\right) = 585\text{ acfm}$$

$\therefore$

$$Q_{BLOWER} \approx 600\text{ acfm}$$

*Allows for practical sized blower.

CLIENT/SUBJECT ______ W.O. NO. ______

TASK DESCRIPTION ______ TASK NO. ______

PREPARED BY ______ DEPT ______ DATE ______

MATH CHECK BY ______ DEPT ______ DATE ______

METHOD REV. BY ______ DEPT ______ DATE ______

APPROVED BY ______ DEPT ______ DATE ______

BLOWER SIZING BASED ON PRESSURE DROP

REQUIREMENTS:

1. Blower must be able to maintain 15"Hg at 300 scfm (14-15"Hg at the wellhead)
2. Horsepower should be low enough to allow operation by a portable generator.
3. Size (footprint) of blower must allow mounting on a trailer. This requirement would be met by almost all blowers. It is anticipated that the blower need only to be transportable throughout the plant

CONFIGURATION:

Three possible configurations have been identified as having potential use at RFP. These configurations, and their associated major specs are provided on the following pages.

ASSUMPTIONS:

$T_{AIR\,IN}$ = 55°F reasonable for air extracting from 15'
Pressure Drop from Piping = 4.6"H_2O (highest for 6")

CLIENT/SUBJECT ______ W.O. NO. ______

TASK DESCRIPTION ______ TASK NO. ______

PREPARED BY ______ DEPT ______ DATE ______

MATH CHECK BY ______ DEPT ______ DATE ______

METHOD REV. BY ______ DEPT ______ DATE ______

APPROVED BY ______

DEPT ______ DATE ______

ASSUMPTIONS (CONT'D):

Pressure Drop from Demister = 5" H_2O (Vendor)
Pressure Drop from HEPA = 8" H_2O (Vendor)
Pressure Drop from Carbon = variable (Q dependent)

Therefore:

Total pressure drop from equipment (except carbon
= 17.6 H_2O = 1.3 Hg

$\boxed{1.3'' \text{ Hg}}$

WESTON
MANAGERS DESIGNERS/CONSULTANTS

CLIENT/SUBJECT ______ W.O. NO. ______

TASK DESCRIPTION ______ TASK NO. ______

PREPARED BY ______ DEPT ______ DATE ______

MATH CHECK BY ______ DEPT ______ DATE ______

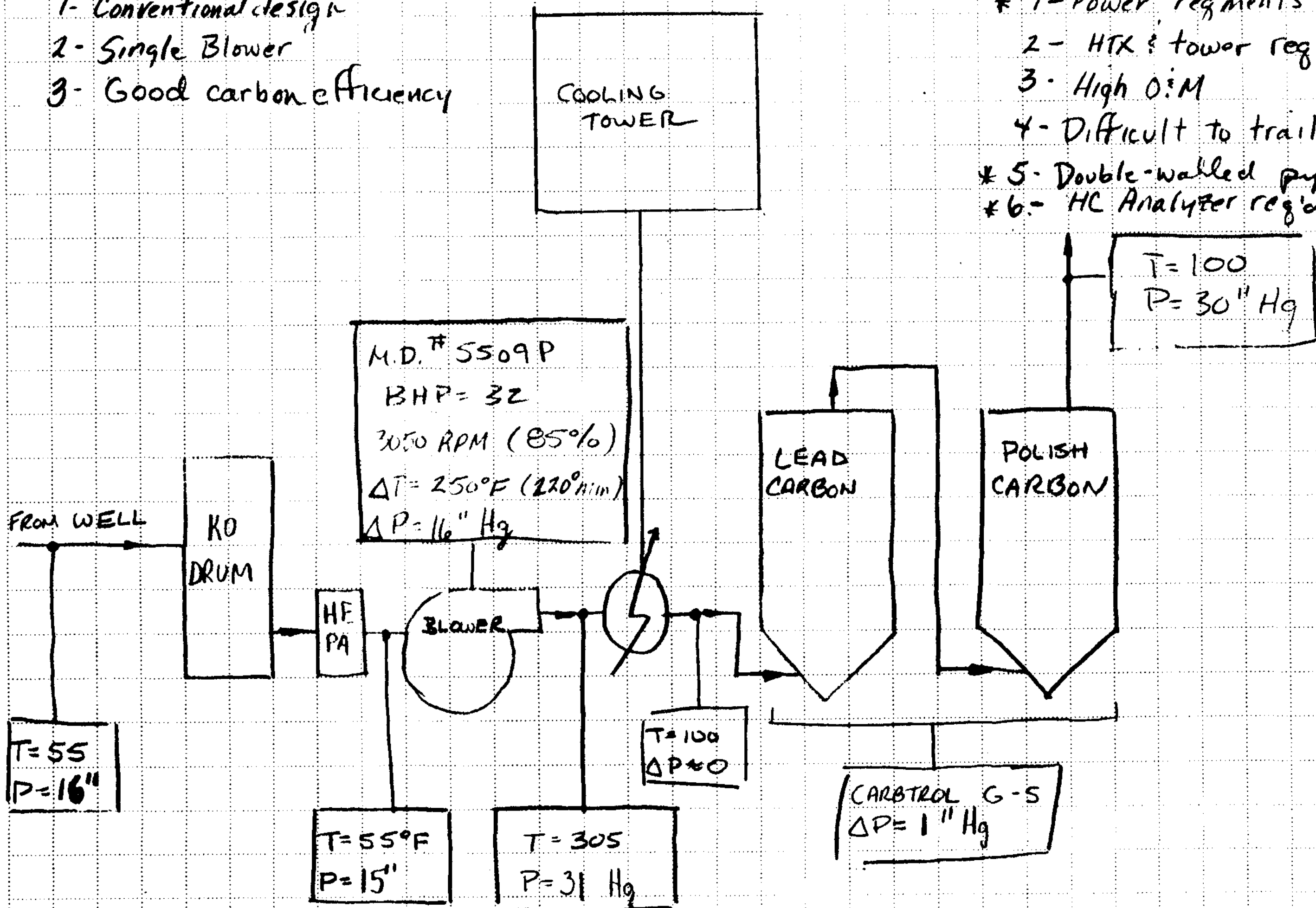
METHOD REV. BY ______ DEPT ______ DATE ______

APPROVED BY ______ DEPT ______ DATE ______

CONFIGURATION #1

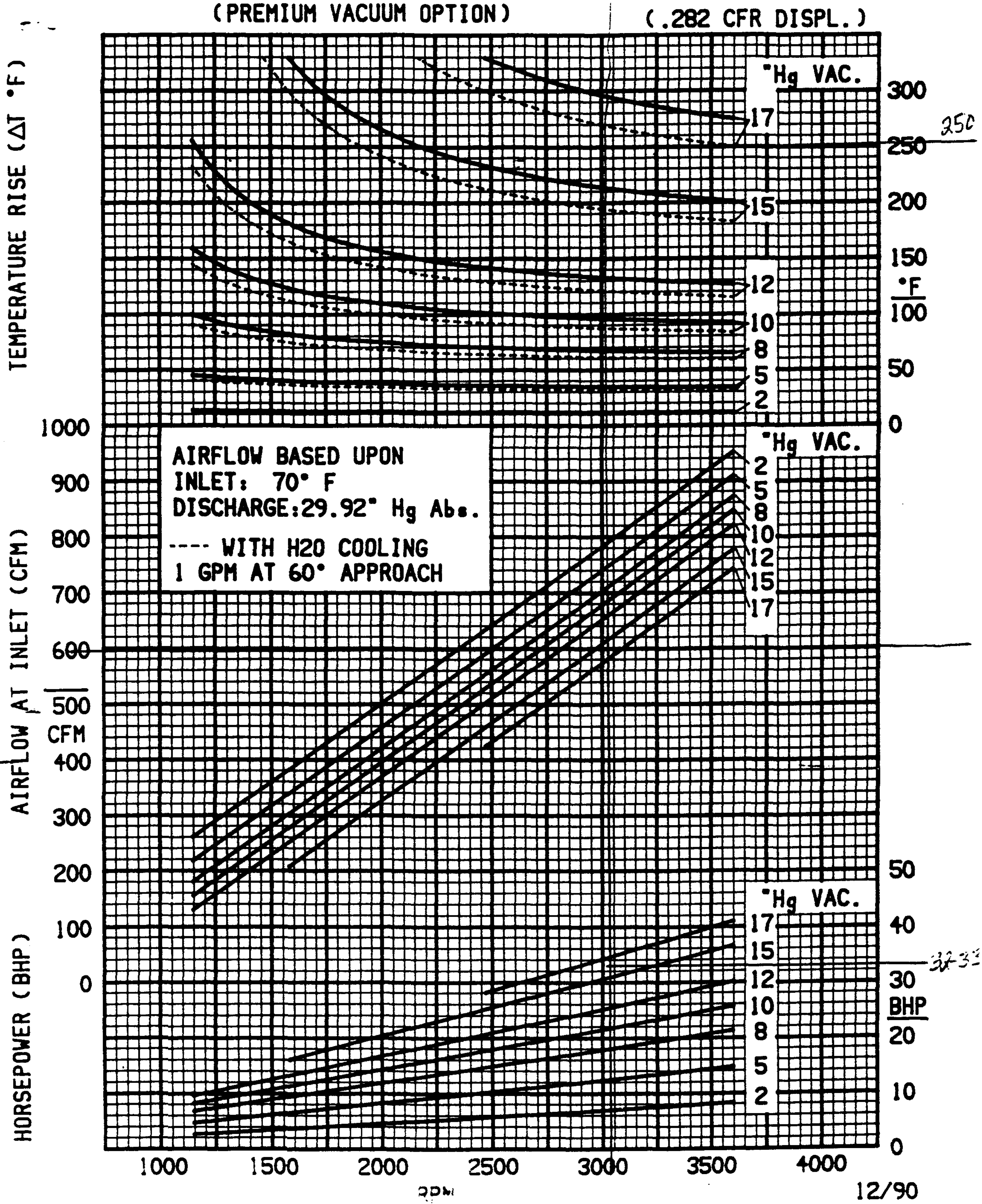
Advantages:
1- Conventional design
2- Single Blower
3- Good carbon efficiency

Disadvantages:
* 1- Power reqments too high
2- HTX & tower req'd
3- High O&M
4- Difficult to trailer mount
* 5- Double-walled pipe req'd
* 6- HC Analyzer req'd



All pressures absolute

5509 VACUUM SLIP CURVE



12/90

WESTON — MANAGERS DESIGNERS/CONSULTANTS

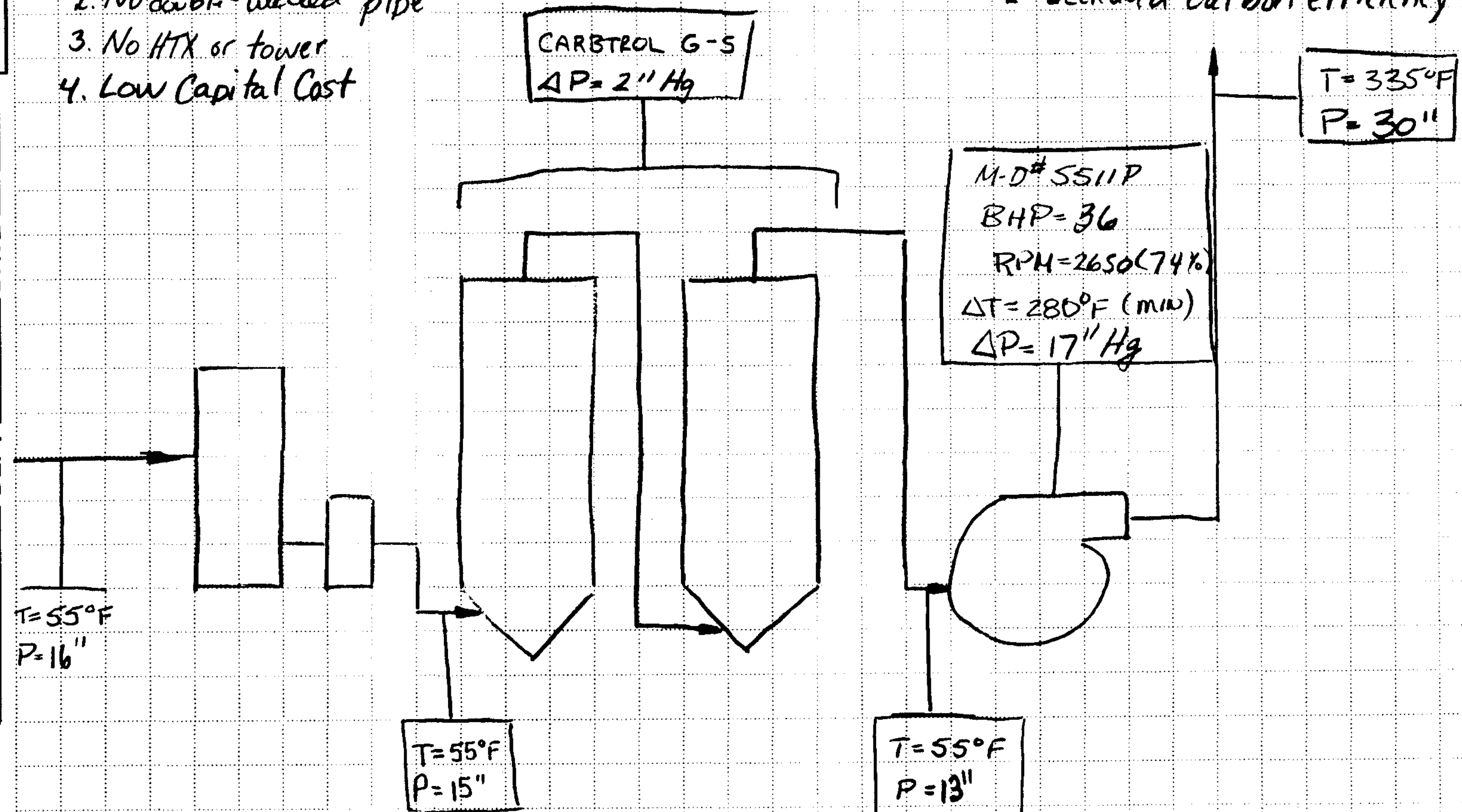
CLIENT/SUBJECT ______ W.O. NO. ______
TASK DESCRIPTION ______ TASK NO. ______
PREPARED BY ______ DEPT ______ DATE ______
MATH CHECK BY ______ DEPT ______ DATE ______
METHOD REV. BY ______ DEPT ______ DATE ______

APPROVED BY ______
DEPT ______ DATE ______

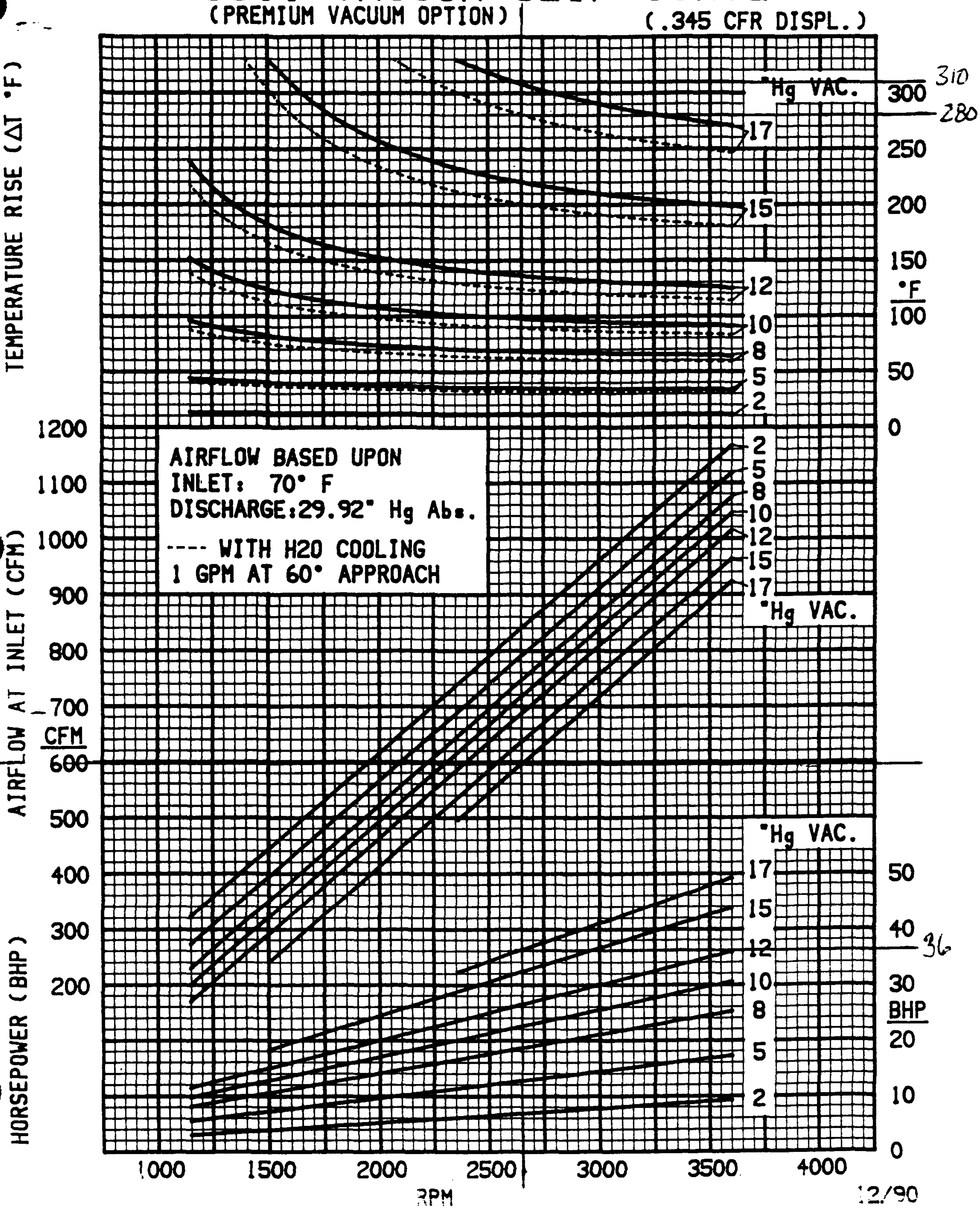
CONFIGURATION #2

Advantages:
1. No HC Analyzer - all under vacuum
2. No double-walled pipe
3. No HTX or tower
4. Low Capital Cost

Disadvantages:
1- At limits of P-D technology
2 - Decreased carbon efficiency



5511 VACUUM SLIP CURVE



WESTON
MANAGERS DESIGNERS/CONSULTANTS

SHEET 5 of 5

CLIENT/SUBJECT ______ W.O. NO. ______

TASK DESCRIPTION ______ TASK NO. ______

PREPARED BY ______ DEPT ______ DATE ______

MATH CHECK BY ______ DEPT ______ DATE ______

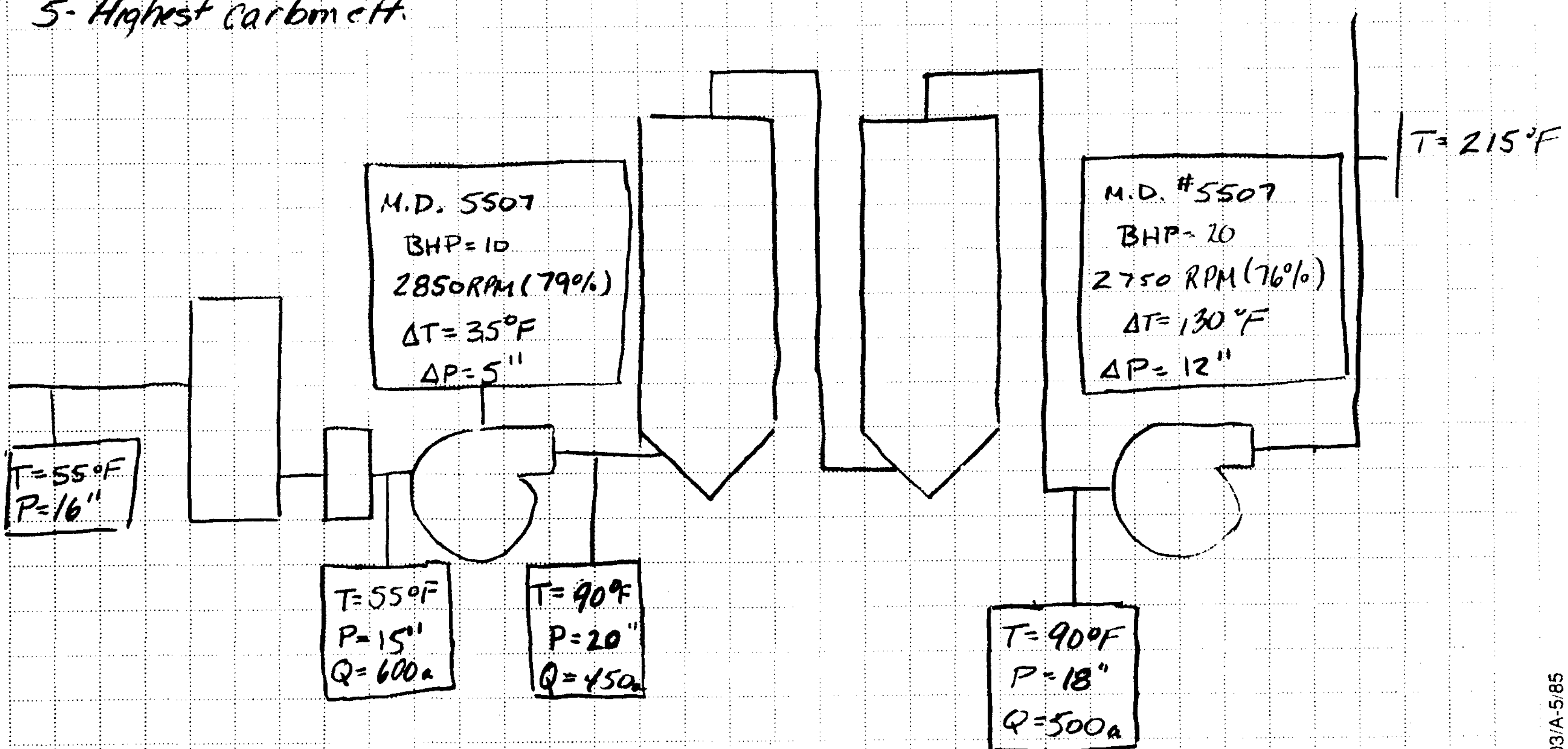
METHOD REV. BY ______ DEPT ______ DATE ______

APPROVED BY ______ DEPT ______ DATE ______

CONFIGURATION #3

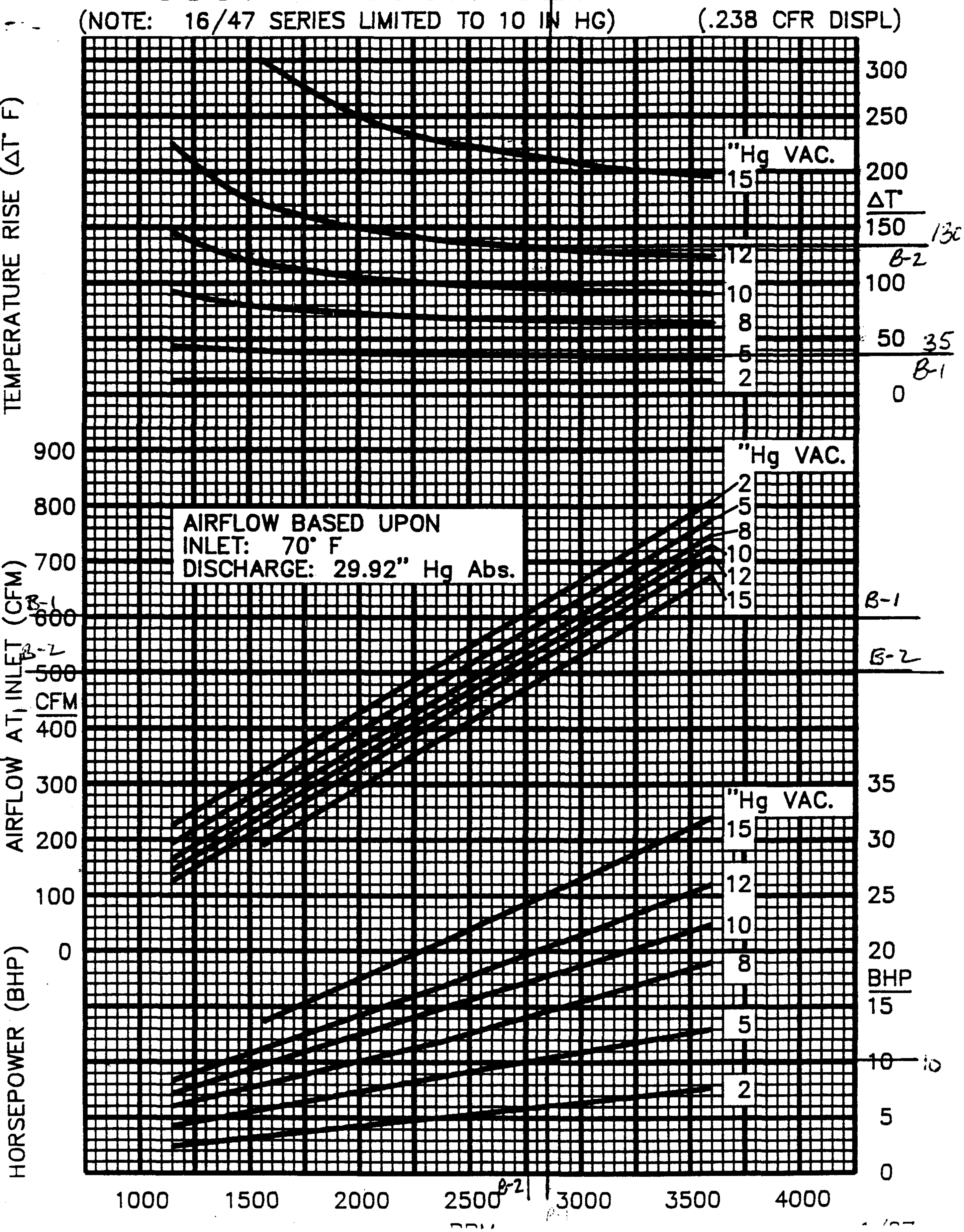
Advantages:
1- No HC Analyzer
2- No double-walled pipe
3- No HTX or tower
4- Lowest Power Req'ments
5- Highest carbon eff.

Disadvantages:
1- Potentially higher capital costs.



SELECT FOR USE

5507 VACUUM SLIP CURVE



WESTON

SHEET 1 of 7

CLIENT/SUBJECT Dressure Drop / RFP W.O. NO.

TASK DESCRIPTION Manifold TASK NO.

PREPARED BY MFK DEPT DATE

MATH CHECK BY DEPT DATE

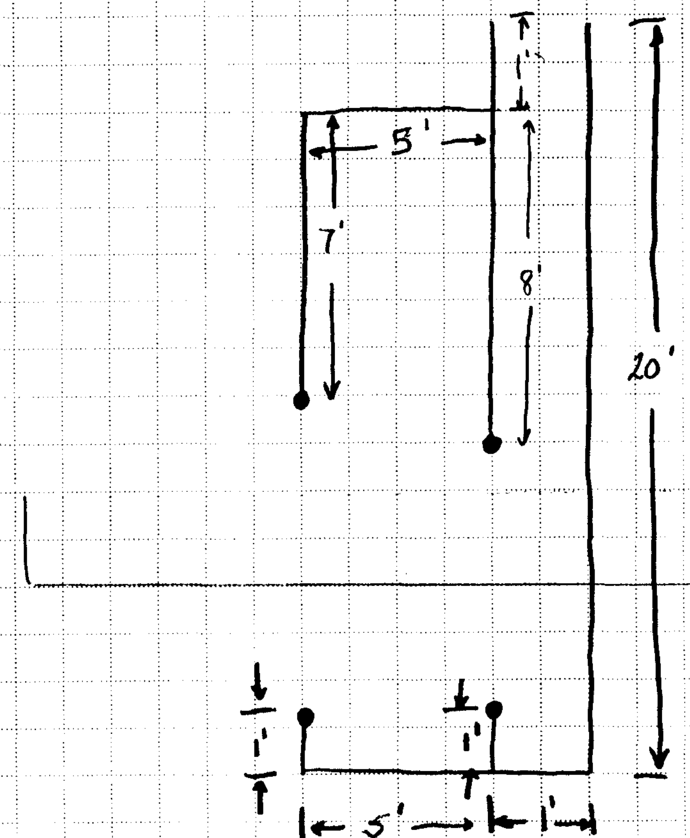
METHOD REV. BY DEPT DATE

APPROVED BY

DEPT DATE

PRESSURE DROP THROUGH MANIFOLD

ALL DISTANCES ARE APPROXIMATE



	AV1	SV1	AV1 + SV1 (assume 60% flow through AV1)
STRAIGHT PIPE	13'	9'	1' @ 600, 8' @ 240, 12' @ 360
90° ELBOWS	3	1	1 @ 240, 3 @ 360
VALVES	1	1	1 @ 240, 1 @ 360
FLOW RATE	600	600	VARIABLE AS INDICATED
ΔP (4"/6")	12.6/4.6	7.4/3.7	5.8/2.3 (in "H_2O)

RFP ISV - AV1 - 6" PIPE

SYSTEM CONFIGURATION		INDIVIDUAL PRESSURE DROP (in. water)	GROUP PRESSURE DROP (in.water)
13	ft. of 6 in. ID Pipe at 600 cfm	0.315	
1	4 in. 90 degree Elbows at 600 cfm	2.192	
2	6 in. 90 degree Elbows at 600 cfm	0.764	
1	6 in. Butterfly Valves at 600 cfm	0.573	
1	6 X 4 in. Reducers at 600 cfm	0.733	

Total pressure drop through Straight Pipes	0.315
Total pressure drop through 90 degree Elbows	2.956
Total pressure drop through Butterfly Valves	0.573
Total pressure drop through Reducers	0.733
TOTAL PRESSURE DROP THROUGHOUT THE SYSTEM	4.577

f: Crane's Handbook, Chapter 3.

RFP ISV - AV1 - 4" PIPE

SYSTEM CONFIGURATION		INDIVIDUAL PRESSURE DROP (in. water)	GROUP PRESSURE DROP (in.water)
13	ft. of 4 in. ID Pipe at 600 cfm	2.713	
3	4 in. 90 degree Elbows at 600 cfm	6.576	
1	4 in. Butterfly Valves at 600 cfm	3.288	
Total pressure drop through Straight Pipes			2.713
Total pressure drop through 90 degree Elbows			6.576
Total pressure drop through Butterfly Valves			3.288
TOTAL PRESSURE DROP THROUGHOUT THE SYSTEM			12.577

Ref: Crane's Handbook, Chapter 3.

RFP ISV - SV1 - 6" PIPE

	SYSTEM CONFIGURATION	INDIVIDUAL PRESSURE DROP (in. water)	GROUP PRESSURE DROP (in.water)
9	ft. of 6 in. ID Pipe at 600 cfm	0.218	
1	4 in. 90 degree Elbows at 600 cfm	2.192	
1	6 in. Butterfly Valves at 600 cfm	0.573	
1	6 X 4 in. Reducers at 600 cfm	0.733	

Total pressure drop through Straight Pipes	0.218
Total pressure drop through 90 degree Elbows	2.192
Total pressure drop through Butterfly Valves	0.573
Total pressure drop through Reducers	0.733

TOTAL PRESSURE DROP THROUGHOUT THE SYSTEM	3.716

Ref: Crane's Handbook, Chapter 3.

RFP ISV - SV1 - 4" PIPE

SYSTEM CONFIGURATION		INDIVIDUAL PRESSURE DROP (in. water)	GROUP PRESSURE DROP (in.water)
9	ft. of 4 in. ID Pipe at 600 cfm	1.878	
1	4 in. 90 degree Elbows at 600 cfm	2.192	
1	4 in. Butterfly Valves at 600 cfm	3.288	

Total pressure drop through Straight Pipes	1.878
Total pressure drop through 90 degree Elbows	2.192
Total pressure drop through Butterfly Valves	3.288
TOTAL PRESSURE DROP THROUGHOUT THE SYSTEM	7.358

Ref: Crane's Handbook, Chapter 3.

RFP ISV - TOTAL - 6" PIPE

SYSTEM CONFIGURATION		INDIVIDUAL PRESSURE DROP (in. water)	GROUP PRESSURE DROP (in.water)
1	ft. of 6 in. ID Pipe at 600 cfm	0.024	
8	ft. of 6 in. ID Pipe at 240 cfm	0.031	
12	ft. of 6 in. ID Pipe at 360 cfm	0.105	
1	4 in. 90 degree Elbows at 240 cfm	0.351	
1	4 in. 90 degree Elbows at 360 cfm	0.789	
2	6 in. 90 degree Elbows at 360 cfm	0.275	
1	6 in. Butterfly Valves at 240 cfm	0.092	
1	6 in. Butterfly Valves at 360 cfm	0.206	
1	6 X 4 in. Reducers at 240 cfm	0.117	
1	6 X 4 in. Reducers at 360 cfm	0.264	
Total pressure drop through Straight Pipes			0.160
Total pressure drop through 90 degree Elbows			1.415
Total pressure drop through Butterfly Valves			0.298
Total pressure drop through Reducers			0.381
TOTAL PRESSURE DROP THROUGHOUT THE SYSTEM			2.254

Ref: Crane's Handbook, Chapter 3.

RFP ISV - TOTAL - 4" PIPE

SYSTEM CONFIGURATION		INDIVIDUAL PRESSURE DROP (in. water)	GROUP PRESSURE DROP (in.water)
1	ft. of 4 in. ID Pipe at 600 cfm	0.209	
8	ft. of 4 in. ID Pipe at 240 cfm	0.267	
12	ft. of 4 in. ID Pipe at 360 cfm	0.902	
1	4 in. 90 degree Elbows at 240 cfm	0.351	
3	4 in. 90 degree Elbows at 360 cfm	2.367	
1	4 in. Butterfly Valves at 240 cfm	0.526	
1	4 in. Butterfly Valves at 360 cfm	1.184	
Total pressure drop through Straight Pipes			1.377
Total pressure drop through 90 degree Elbows			2.718
Total pressure drop through Butterfly Valves			1.710
TOTAL PRESSURE DROP THROUGHOUT THE SYSTEM			5.805

Ref: Crane's Handbook, Chapter 3.

CLIENT/SUBJECT ______ W.O. NO. ______
TASK DESCRIPTION ______ TASK NO. ______
PREPARED BY ______ DEPT ______ DATE ______
MATH CHECK BY ______ DEPT ______ DATE ______
METHOD REV. BY ______ DEPT ______ DATE ______

APPROVED BY ______
DEPT ______ DATE ______

AIR INJECTION BLOWER SIZING

POSITIVE PRESSURE PERFORMANCE: The air injection blower for the 3 test site should meet the following conditions:

1. Apply enough pressure, to adequately determine if air injection is beneficial to vapor extraction performance.

2. Not apply too much pressure, such that the pressure differential between extraction and injection points is not significant when compared to the differential between the injection point, and ambient pressure.

An injection pressure of 5 psi (10" Hg) should meet the above criteria

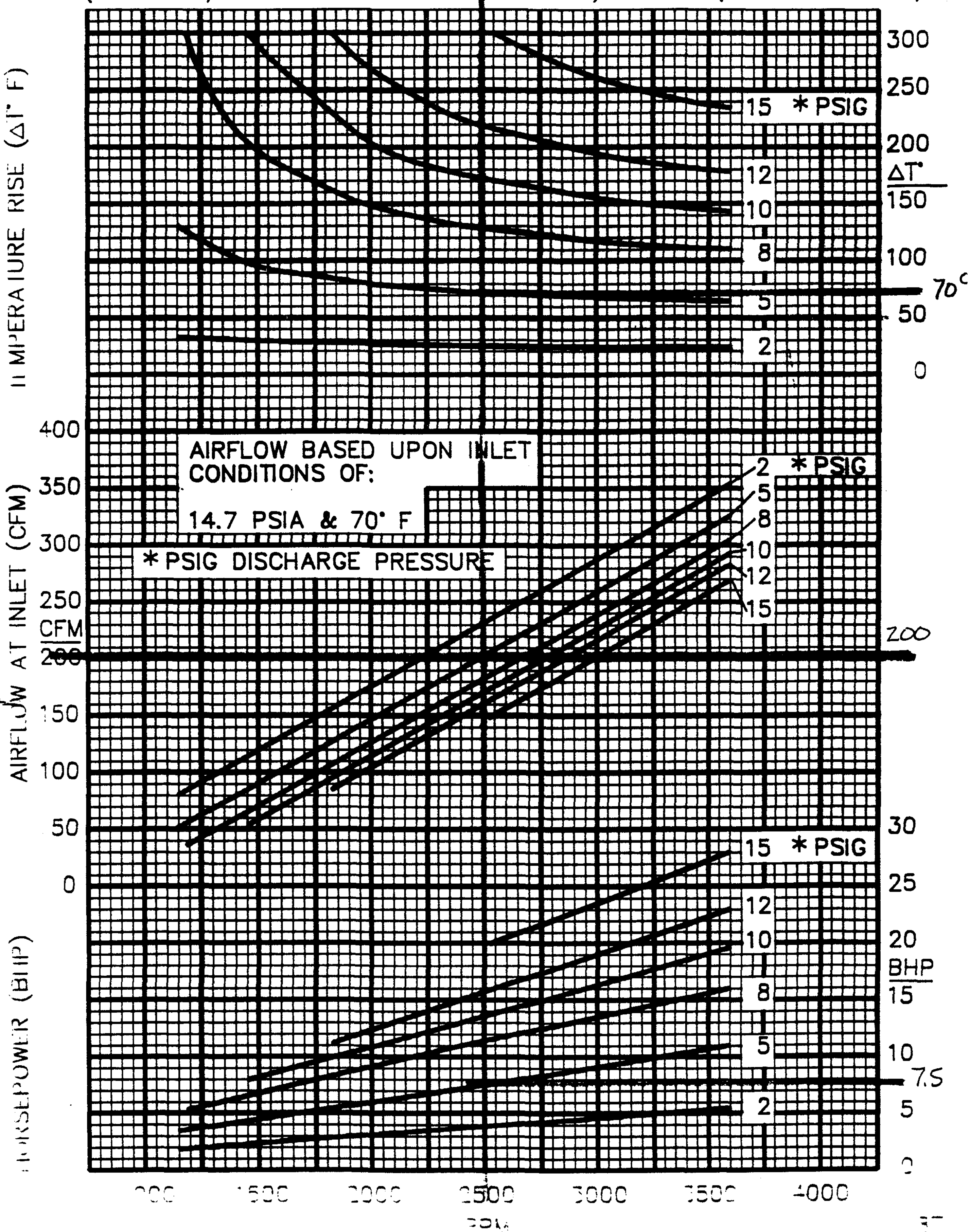
FLOW RATE PERFORMANCE: The flow rate is sized to be 1/2 of the extraction flow rate to ensure that all injected air is extracted, thus minimizing the potential for spreading contaminatio

$$Q = \tfrac{1}{2} Q_{EXTRACTION_{MAX}} \quad 525/2 = 262.5 \text{ scfm}$$

$$Q_{acfm} = (262.5 \text{ scfm})\left(\frac{14.7}{14.7+5}\right) = \boxed{196 \text{ acfm}}$$

3210 PRESSURE SLIP CURVE

(NOTE: 16/47 SERIES LIMITED TO 10 PSIG) (.112 CFR DISPL.)



WESTON
MANAGERS DESIGNERS/CONSULTANTS

SHEET 1 of 1

CLIENT/SUBJECT RFP

W.O. NO. 02029-037-001

TASK DESCRIPTION Groundwater Extraction - Sizing of Holding Tank

TASK NO.

PREPARED BY BAH DEPT DATE

MATH CHECK BY DEPT DATE

METHOD REV. BY DEPT DATE

APPROVED BY

DEPT DATE

Maximum Groundwater Withdrawal Rate = 5 gpm

Daily Extraction Rate = $\frac{5 \text{ gal}}{\text{min}} \Big| \frac{60 \text{ min}}{\text{hr}} \Big| \frac{24 \text{ hr}}{\text{day}}$ 7200 gal/day

Above Ground Holding Tank Size Selected = 10,000 gallons (Standard Size)

Tank Dimensions = 8' Diameter

(as per Beta Tank, Inc.) 26'5" Length

At 5 gpm extraction rate, tank will fill in 1.4 days

RFW 10-05-003/A-5/85

SHEET 1 of 6

CLIENT/SUBJECT EG&G W.O. NO. 2029-37-01

TASK DESCRIPTION TASK NO. 0130

PREPARED BY MAD	DEPT W582	DATE 12/31/92	APPROVED BY	
MATH CHECK BY KFN	DEPT W582	DATE 1/8/93		
METHOD REV. BY KFN	DEPT W582	DATE 1/8/93	DEPT	DATE

Purpose: Estimate drawdown in unconfined aquifer resulting from pumping at dewatering well(s).

Methods: Use Theis Equation (1) for "ideal" confined aquifers. Calculate equivalent unconfined drawdown using method proposed by Jacob (2)

Assumptions:

Aquifer and pumping parameters:

- t = 5 days — length of pilot test
- K = 1.15 ft/day — document
- b = 36 ft — "
- S = 0.21 — average specific yield for fine sand, from Fetter (3)
- Q = variable (pumping rate)

Ideal aquifer and pumping assumptions:

- The aquifer is confined.
- The aquifer has an infinite areal extent.
- The aquifer is homogeneous, isotropic, and of uniform thickness over the area influenced by the pumping test.
- The aquifer is pumped at a constant discharge rate
- The pumped well penetrates the entire aquifer and thus receives water from the entire thickness of the aquifer by horizontal flow.

WESTON
MANAGERS DESIGNERS/CONSULTANTS

CLIENT/SUBJECT EG&G — W.O. NO. 2029-37-01
TASK DESCRIPTION — TASK NO. 0130
PREPARED BY MAD — DEPT W582 — DATE 12/31/92 — APPROVED BY
MATH CHECK BY KFW — DEPT W582 — DATE 1/8/93
METHOD REV. BY KFW — DEPT W582 — DATE 1/8/93 — DEPT ___ DATE ___

Results:

(1) Theis Equation:

drawdown $s = \frac{Q}{4\pi Kb} W(u)$

where well function, $W(u)$ is tabulated (page 3), and $u = \frac{r^2 S}{4Kbt}$ (r = distance from well)

Because we want approximate drawdown in pumping well, assume $r = 0.5$ ft (4-inch well in 1-foot diameter borehole).

$$u = \frac{(0.5 ft)^2 (0.21)}{4(1.15 ft/day)(36 ft)(5 day)} = 6.34 \times 10^{-5}$$

Interpolate $W(u)$ using:

$$W(u) = W(u_2) - \frac{(u_2 - u)(W(u_2) - W(u_1))}{(u_2 - u_1)}$$

$$= 9.0795 - \frac{(6.4E-5 - 6.34E-5)(9.0795 - 9.0952)}{(6.4E-5 - 6.3E-5)}$$

$$= 9.0890$$

$$s = \frac{(2.5 gal/min)(1440 min/day)(9.0890)}{4\pi (1.15 ft/day)(36 ft)(7.48 gal/ft^3)} = \underline{\underline{8.41 ft}}$$

TABLE 5.—*Values of* W(u) *for values of* u *between* 10^{-15} *and 9.9*

[From Ferris, Knowles, Brown, and Stallman (1962, p. 96)]

N \ u	$N\times10^{-15}$	$N\times10^{-14}$	$N\times10^{-13}$	$N\times10^{-12}$	$N\times10^{-11}$	$N\times10^{-10}$	$N\times10^{-9}$	$N\times10^{-8}$	$N\times10^{-7}$	$N\times10^{-6}$	$N\times10^{-5}$	$N\times10^{-4}$	$N\times10^{-3}$	$N\times10^{-2}$	$N\times10^{-1}$	N
1.0	33.9616	31.6590	29.3564	27.0538	24.7512	22.4486	20.1460	17.8435	15.5409	13.2383	10.9357	8.6332	6.3315	4.0379	1.8229	0.2194
1.1	33.8662	31.5637	29.2611	26.9585	24.6559	22.3533	20.0507	17.7482	15.4456	13.1430	10.8404	8.5379	6.2363	3.9436	1.7371	.1860
1.2	33.7792	31.4767	29.1741	26.8715	24.5689	22.2663	19.9637	17.6611	15.3586	13.0560	10.7534	8.4509	6.1494	3.8576	1.6595	.1584
1.3	33.6992	31.3966	29.0940	26.7914	24.4889	22.1863	19.8837	17.5811	15.2785	12.9759	10.6734	8.3709	6.0695	3.7785	1.5889	.1355
1.4	33.6251	31.3225	29.0199	26.7173	24.4147	22.1122	19.8096	17.5070	15.2044	12.9018	10.5993	8.2968	5.9955	3.7054	1.5241	.1162
1.5	33.5561	31.2535	28.9509	26.6483	24.3458	22.0432	19.7406	17.4380	15.1354	12.8328	10.5303	8.2278	5.9266	3.6374	1.4645	.1000
1.6	33.4916	31.1890	28.8864	26.5838	24.2812	21.9786	19.6760	17.3735	15.0709	12.7683	10.4657	8.1634	5.8621	3.5739	1.4092	.08631
1.7	33.4309	31.1283	28.8258	26.5232	24.2206	21.9180	19.6154	17.3128	15.0103	12.7077	10.4051	8.1027	5.8016	3.5143	1.3578	.07465
1.8	33.3738	31.0712	28.7686	26.4660	24.1634	21.8608	19.5583	17.2557	14.9531	12.6505	10.3479	8.0455	5.7446	3.4581	1.3089	.06471
1.9	33.3197	31.0171	28.7145	26.4119	24.1094	21.8068	19.5042	17.2016	14.8990	12.5964	10.2939	7.9915	5.6906	3.4050	1.2649	.05620
2.0	33.2684	30.9658	28.6632	26.3607	24.0581	21.7555	19.4529	17.1503	14.8477	12.5451	10.2426	7.9402	5.6394	3.3547	1.2227	.04890
2.1	33.2196	30.9170	28.6145	26.3119	24.0093	21.7067	19.4041	17.1015	14.7989	12.4964	10.1938	7.8914	5.5907	3.3069	1.1829	.04261
2.2	33.1731	30.8705	28.5679	26.2653	23.9628	21.6602	19.3576	17.0550	14.7524	12.4498	10.1473	7.8449	5.5443	3.2614	1.1454	.03719
2.3	33.1286	30.8261	28.5235	26.2209	23.9183	21.6157	19.3131	17.0106	14.7080	12.4054	10.1028	7.8004	5.4999	3.2179	1.1099	.03250
2.4	33.0861	30.7835	28.4809	26.1783	23.8758	21.5732	19.2706	16.9680	14.6654	12.3628	10.0603	7.7579	5.4575	3.1763	1.0762	.02844
2.5	33.0453	30.7427	28.4401	26.1375	23.8349	21.5323	19.2298	16.9272	14.6246	12.3220	10.0194	7.7172	5.4167	3.1365	1.0443	.02491
2.6	33.0060	30.7035	28.4009	26.0983	23.7957	21.4931	19.1905	16.8880	14.5854	12.2828	9.9802	7.6779	5.3776	3.0983	1.0139	.02185
2.7	32.9683	30.6657	28.3631	26.0606	23.7580	21.4554	19.1528	16.8502	14.5476	12.2450	9.9425	7.6401	5.3400	3.0615	.9849	.01918
2.8	32.9319	30.6294	28.3268	26.0242	23.7216	21.4190	19.1164	16.8138	14.5113	12.2087	9.9061	7.6038	5.3037	3.0261	.9573	.01686
2.9	32.8968	30.5943	28.2917	25.9891	23.6865	21.3839	19.0813	16.7788	14.4762	12.1736	9.8710	7.5687	5.2687	2.9920	.9309	.01482
3.0	32.8629	30.5604	28.2578	25.9552	23.6526	21.3500	19.0474	16.7449	14.4423	12.1397	9.8371	7.5348	5.2349	2.9591	.9057	.01305
3.1	32.8302	30.5276	28.2250	25.9224	23.6198	21.3172	19.0146	16.7121	14.4095	12.1069	9.8043	7.5020	5.2022	2.9273	.8815	.01149
3.2	32.7984	30.4958	28.1932	25.8907	23.5880	21.2855	18.9829	16.6803	14.3777	12.0751	9.7726	7.4703	5.1706	2.8965	.8583	.01013
3.3	32.7676	30.4651	28.1625	25.8599	23.5573	21.2547	18.9521	16.6495	14.3470	12.0444	9.7418	7.4395	5.1399	2.8668	.8361	.008939
3.4	32.7378	30.4352	28.1326	25.8300	23.5274	21.2249	18.9223	16.6197	14.3171	12.0145	9.7120	7.4097	5.1102	2.8379	.8147	.007891
3.5	32.7088	30.4062	28.1036	25.8010	23.4985	21.1959	18.8933	16.5907	14.2881	11.9855	9.6830	7.3807	5.0813	2.8099	.7942	.006970
3.6	32.6806	30.3780	28.0755	25.7729	23.4703	21.1677	18.8651	16.5625	14.2599	11.9574	9.6548	7.3526	5.0532	2.7827	.7745	.006160
3.7	32.6532	30.3506	28.0481	25.7455	23.4429	21.1403	18.8377	16.5351	14.2325	11.9300	9.6274	7.3252	5.0259	2.7563	.7554	.005448
3.8	32.6266	30.3240	28.0214	25.7188	23.4162	21.1136	18.8110	16.5085	14.2059	11.9033	9.6007	7.2985	4.9993	2.7306	.7371	.004820
3.9	32.6006	30.2980	27.9954	25.6928	23.3902	21.0877	18.7851	16.4825	14.1799	11.8773	9.5748	7.2725	4.9735	2.7056	.7194	.004267
4.0	32.5753	30.2727	27.9701	25.6675	23.3649	21.0623	18.7598	16.4572	14.1546	11.8520	9.5495	7.2472	4.9482	2.6813	.7024	.003779
4.1	32.5506	30.2480	27.9454	25.6428	23.3402	21.0376	18.7351	16.4325	14.1299	11.8273	9.5248	7.2225	4.9236	2.6576	.6859	.003349
4.2	32.5265	30.2239	27.9213	25.6187	23.3161	21.0136	18.7110	16.4084	14.1058	11.8032	9.5007	7.1985	4.8997	2.6344	.6700	.002969
4.3	32.5029	30.2004	27.8978	25.5952	23.2926	20.9900	18.6874	16.3884	14.0823	11.7797	9.4771	7.1749	4.8762	2.6119	.6546	.002633
4.4	32.4800	30.1774	27.8748	25.5722	23.2696	20.9670	18.6644	16.3619	14.0593	11.7367	9.4541	7.1520	4.8533	2.5899	.6397	.002336
4.5	32.4575	30.1519	27.8523	25.5497	23.2471	20.9446	18.6420	16.3394	14.0368	11.7342	9.4317	7.1295	4.8310	2.5684	.6253	.002073
4.6	32.4355	30.1329	27.8303	25.5277	23.2252	20.9226	18.6200	16.3174	14.0148	11.7122	9.4097	7.1075	4.8091	2.5474	.6114	.001841
4.7	32.4140	30.1114	27.8088	25.5062	23.2037	20.9011	18.5985	16.2959	13.9933	11.6907	9.3882	7.0860	4.7877	2.5268	.5979	.001635
4.8	32.3929	30.0004	27.7878	25.4852	23.1826	20.8800	18.5774	16.2748	13.9723	11.6697	9.3671	7.0650	4.7667	2.5068	.5848	.001453
4.9	32.3723	30.0697	27.7672	25.4646	23.1620	20.8594	18.5568	16.2542	13.9516	11.6491	9.3465	7.0444	4.7462	2.4871	.5721	.001291
5.0	32.3521	30.0495	27.7470	25.4444	23.1418	20.8392	18.5366	16.2340	13.9314	11.6289	9.3263	7.0242	4.7261	2.4679	.5598	.001148
5.1	32.3323	30.0297	27.7271	25.4246	23.1220	20.8194	18.5168	16.2142	13.9116	11.6091	9.3065	7.0044	4.7064	2.4491	.5478	.001021
5.2	32.3129	30.0103	27.7077	25.4051	23.1026	20.8000	18.4974	16.1948	13.8922	11.5896	9.2871	6.9850	4.6871	2.4306	.5362	.0009086
5.3	32.2939	29.9913	27.6887	25.3861	23.0835	20.7809	18.4783	16.1758	13.8732	11.5706	9.2681	6.9659	4.6681	2.4126	.5250	.0008086
5.4	32.2752	29.9726	27.6700	25.3674	23.0648	20.7622	18.4596	16.1571	13.8545	11.5519	9.2494	6.9473	4.6495	2.3948	.5140	.0007198
5.5	32.2568	29.9542	27.6516	25.3491	23.0465	20.7439	18.4413	16.1387	13.8361	11.5336	9.2310	6.9289	4.6313	2.3775	.5034	.0006409
5.6	32.2388	29.9362	27.6336	25.3310	23.0285	20.7259	18.4233	16.1207	13.8181	11.5155	9.2130	6.9109	4.6134	2.3604	.4930	.0005708
5.7	32.2211	29.9185	27.6159	25.3133	23.0108	20.7082	18.4056	16.1030	13.8004	11.4978	9.1953	6.8932	4.5958	2.3437	.4830	.0005085
5.8	32.2037	29.9011	27.5985	25.2959	22.9934	20.6908	18.3882	16.0856	13.7830	11.4804	9.1779	6.8758	4.5785	2.3273	.4732	.0004532
5.9	32.1866	29.8840	27.5814	25.2789	22.9763	20.6737	18.3711	16.0685	13.7659	11.4633	9.1608	6.8588	4.5615	2.3111	.4637	.0004039
6.0	32.1698	29.8672	27.5646	25.2620	22.9595	20.6569	18.3543	16.0517	13.7491	11.4465	9.1440	6.8420	4.5448	2.2953	.4544	.0003601
6.1	32.1533	29.8507	27.5481	25.2455	22.9429	20.6403	18.3378	16.0352	13.7326	11.4300	9.1275	6.8254	4.5283	2.2797	.4454	.0003211
6.2	32.1370	29.8344	27.5318	25.2293	22.9267	20.6241	18.3215	16.0189	13.7163	11.4138	9.1112	6.8092	4.5122	2.2645	.4366	.0002864
6.3	32.1210	29.8184	27.5158	25.2133	22.9107	20.6081	18.3055	16.0029	13.7003	11.3978	9.0952	6.7932	4.4963	2.2494	.4280	.0002555
6.4	32.1053	29.8027	27.5001	25.1975	22.8949	20.5923	18.2898	15.9872	13.6846	11.3820	9.0795	6.7775	4.4806	2.2346	.4197	.0002279
6.5	32.0898	29.7872	27.4846	25.1820	22.8794	20.5768	18.2742	15.9717	13.6691	11.3665	9.0640	6.7620	4.4652	2.2201	.4115	.0002034
6.6	32.0745	29.7719	27.4693	25.1667	22.8641	20.5616	18.2590	15.9564	13.6538	11.3512	9.0487	6.7467	4.4501	2.2058	.4036	.0001816
6.7	32.0595	29.7569	27.4543	25.1517	22.8491	20.5465	18.2439	15.9414	13.6388	11.3362	9.0337	6.7317	4.4351	2.1917	.3959	.0001621
6.8	32.0446	29.7421	27.4395	25.1369	22.8343	20.5317	18.2291	15.9265	13.6240	11.3214	9.0189	6.7169	4.4204	2.1779	.3883	.0001448
6.9	32.0300	29.7275	27.4249	25.1223	22.8197	20.5171	18.2145	15.9119	13.6094	11.3608	9.0043	6.7023	4.4059	2.1643	.3810	.0001293
7.0	32.0156	29.7131	27.4105	25.1079	22.8053	20.5027	18.2001	15.8976	13.5950	11.2924	8.9899	6.6879	4.3916	2.1508	.3738	.0001155
7.1	32.0015	29.6989	27.3063	25.0937	22.7911	20.4885	18.1860	15.8834	13.5808	11.2782	8.9757	6.6737	4.3775	2.1376	.3669	.0001032
7.2	31.9875	29.6849	27.3823	25.0797	22.7771	20.4746	18.1720	15.8694	13.5668	11.2642	8.9617	6.6598	4.3636	2.1246	.3599	.00009219
7.3	31.9737	29.6711	27.3685	25.0659	22.7633	20.4608	18.1582	15.8556	13.5530	11.2504	8.9479	6.6460	4.3500	2.1118	.3532	.00008239
7.4	31.9601	29.6575	27.3549	25.0523	22.7497	20.4472	18.1446	15.8420	13.5394	11.2368	8.9343	6.6324	4.3364	2.0991	.3467	.00007364
7.5	31.9467	29.6441	27.3415	25.0389	22.7363	20.4337	18.1311	15.8286	13.5260	11.2234	8.9209	6.6190	4.3231	2.0867	.3403	.00006583
7.6	31.9334	29.6308	27.3282	25.0257	22.7231	20.4205	18.1179	15.8153	13.5127	11.2102	8.9076	6.6057	4.3100	2.0744	.3341	.00005886
7.7	31.9203	29.6178	27.3152	25.0126	22.7100	20.4074	18.1048	15.8022	13.4997	11.1971	8.8946	6.5927	4.2970	2.0623	.3280	.00005263
7.8	31.9074	29.6048	27.3023	24.9997	22.6971	20.3945	18.0919	15.7893	13.4868	11.1842	8.8817	6.5798	4.2842	2.0503	.3221	.00004707
7.9	31.8947	29.5921	27.2895	24.9869	22.6844	20.3818	18.0792	15.7766	13.4740	11.1714	8.8689	6.5671	4.2716	2.0386	.3163	.00004210
8.0	31.8821	29.5795	27.2769	24.9744	22.6718	20.3692	18.0666	15.7640	13.4614	11.1589	8.8563	6.5546	4.2591	2.0269	.3106	.00003767
8.1	31.8697	29.5671	27.2645	24.9619	22.6594	20.3568	18.0542	15.7516	13.4490	11.1464	8.8439	6.5421	4.2468	2.0155	.3050	.00003370
8.2	31.8574	29.5548	27.2523	24.9497	22.6471	20.3445	18.0419	15.7393	13.4367	11.1342	8.8317	6.5298	4.2346	2.0042	.2996	.00003015
8.3	31.8453	29.5427	27.2401	24.9375	22.6350	20.3324	18.0298	15.7272	13.4246	11.1220	8.8195	6.5177	4.2226	1.9930	.2943	.00002699
8.4	31.8333	29.5307	27.2282	24.9256	22.6230	20.3204	18.0178	15.7152	13.4126	11.1101	8.8076	6.5057	4.2107	1.9820	.2891	.00002415
8.5	31.8215	29.5189	27.2163	24.9137	22.6112	20.3086	18.0060	15.7034	13.4008	11.0982	8.7957	6.4939	4.1990	1.9711	.2840	.00002162
8.6	31.8098	29.5072	27.2046	24.9020	22.5995	20.2969	17.9943	15.6917	13.3891	11.0865	8.7840	6.4822	4.1874	1.9604	.2790	.00001936
8.7	31.7982	29.4957	27.1931	24.8905	22.5879	20.2853	17.9827	15.6801	13.3776	11.0750	8.7725	6.4707	4.1759	1.9498	.2742	.00001733
8.8	31.7868	29.4842	27.1816	24.8790	22.5765	20.2739	17.9713	15.6687	13.3661	11.0635	8.7610	6.4592	4.1646	1.9393	.2694	.00001552
8.9	31.7755	29.4729	27.1703	24.8678	22.5652	20.2626	17.9600	15.6574	13.3548	11.0523	8.7497	6.4480	4.1534	1.9290	.2647	.00001390
9.0	31.7643	29.4618	27.1592	24.8566	22.5540	20.2514	17.9488	15.6462	13.3437	11.0411	8.7386	6.4368	4.1423	1.9187	.2602	.00001245
9.1	31.7533	29.4507	27.1481	24.8455	22.5429	20.2404	17.9378	15.6352	13.3326	11.0300	8.7275	6.4258	4.1313	1.9087	.2557	.00001115
9.2	31.7424	29.4398	27.1372	24.8346	22.5320	20.2294	17.9268	15.6243	13.3217	11.0191	8.7166	6.4148	4.1205	1.8987	.2513	.000009988
9.3	31.7315	29.4290	27.1264	24.8238	22.5212	20.2186	17.9160	15.6135	13.3109	11.0083	8.7058	6.4040	4.1098	1.8888	.2470	.000008948
9.4	31.7208	29.4183	27.1157	24.8131	22.5105	20.2079	17.9053	15.6028	13.3002	10.9976	8.6951	6.3934	4.0992	1.8791	.2429	.000008018
9.5	31.7103	29.4077	27.1051	24.8025	22.4999	20.1973	17.8948	15.5922	13.2896	10.9870	8.6845	6.3828	4.0887	1.8695	.2387	.000007185
9.6	31.6998	29.3972	27.0946	24.7920	22.4895	20.1869	17.8843	15.5817	13.2791	10.9765	8.6740	6.3723	4.0784	1.8599	.2347	.000006439
9.7	31.6894	29.3868	27.0843	24.7817	22.4791	20.1765	17.8739	15.5713	13.2688	10.9662	8.6637	6.3620	4.0681	1.8505	.2308	.000005771
9.8	31.6792	29.3766	27.0740	24.7714	22.4688	20.1663	17.8637	15.5611	13.2585	10.9559	8.6534	6.3517	4.0579	1.8412	.2269	.000005173
9.9	31.6690	29.3664	27.0639	24.7613	22.4587	20.1561	17.8535	15.5509	13.2483	10.9458	8.6433	6.3416	4.0479	1.8320	.2231	.000004637

CLIENT/SUBJECT EG&G W.O. NO. 2029-37-01
TASK DESCRIPTION TASK NO. 0130
PREPARED BY MAD DEPT W582 DATE 12/31/92
MATH CHECK BY KFW DEPT W582 DATE 1/8/93
METHOD REV. BY KFW DEPT W582 DATE 1/8/93

APPROVED BY
DEPT DATE

(2) Jacob determined that confined drawdown (s) for a given aquifer can be related to equivalent unconfined drawdown (s_e) by the following equation:

$$s = s_e - \frac{s_e^2}{2b}$$

Solving for s_e by iteration (not shown)

$$(8.41) = (9.72) - \frac{(9.72)^2}{2(36)}$$

$$s_e \simeq \underline{\underline{9.72 \text{ ft}}}$$

(3) Tabulate values of s and s_e for different pumping rates:

Q(gpm)	s(ft)	s_e(ft)
1.5	5.04	5.45
2.5	8.41	9.72
5	16.81	26.75

CLIENT/SUBJECT EG&G W.O. NO. 2029-37-01

TASK DESCRIPTION TASK NO. 0130

PREPARED BY MAD	DEPT W582	DATE 12/31/92	APPROVED BY
MATH CHECK BY KGN	DEPT W582	DATE 1/8/93	
METHOD REV. BY KGN	DEPT W582	DATE 1/8/93	DEPT DATE

(4) Drawdown in well will also be influenced by pumping from nearby well, spaced at 10 feet. Total drawdown will be additive and can be summarized as follows:

2-well drawdown at well

Q(gpm)	Pumping S_e	Adjacent Well[1] S	Adjacent Well[1] S_e	Total[2] S_e (ft)
1.5	5.45	1.73	1.78	7.23
2.5	9.72	2.89	3.02	12.74
5	26.75	5.78	6.33	33.08

Similarly:

2-well drawdown at midpoint[3]

Q(gpm)	S	S_e	$2 \times S_e$ (ft)
1.5	2.49	2.58	5.16
2.5	4.15	4.42	8.84
5	8.31	9.58	19.16

1) R = 10 feet

2) Total S_e = Pumping S_e + Adjacent Well S_e

3) R = 5 feet

WESTON
MANAGERS DESIGNERS/CONSULTANTS

CLIENT/SUBJECT EG&G W.O. NO. 2029-37-01

TASK DESCRIPTION TASK NO. 0130

PREPARED BY MAD DEPT W582 DATE 12/31/92

MATH CHECK BY KFN DEPT W582 DATE 1/8/93

METHOD REV. BY KFN DEPT W582 DATE 1/8/93

APPROVED BY

DEPT DATE

References:

(1) Theis, C.V., 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground water storage. Transactions, American Geophysical Union, Washington, D.C. pp. 518-524.

(2) Jacob, C.E., 1963. Recovery method for determining the coefficient of transmissibility. U.S. Geological Survey Water Supply Paper 1536 I, Washington, D.C.

(3) Fetter, C.W., 1988. Applied Hydrogeology. Merrill Publishing, Columbus, Ohio, 592 p.

WESTON

SHEET 1 of 4

CLIENT/SUBJECT RFP W.O. NO. 02029-037-001

TASK DESCRIPTION Sizing of Piping for GW Conveyance TASK NO.

PREPARED BY BAH DEPT DATE

MATH CHECK BY DEPT DATE

METHOD REV. BY DEPT DATE

APPROVED BY

DEPT DATE

For groundwater conveyance, piping will be required for the following:

- From SV1
- From SI1
- From Knockdown Drum T-1

Piping System will consist of the following:

- Seperate GW extraction pipes from SV1 and SI1
- Pipes from SV1 and SI1 will be combined into single pipe
- Pipe from knockdown Drum T-1 to connect to pipe for combined flow from SV1 and SI1
- Pipe for total flow

Piping will be sized using the following maximum flowrates for the specific sections:

- From SV1 - 2.5 gpm
- From SI1 - 2.5 gpm
- Combined SV1 and SI1 - 5 gpm
- From Knockdown Drum T-1 - 5 gpm
- Total combined flow - 10 gpm

Optimum pipe diameters sized for each segment using nomograph (Source: Figure 13-2 from Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers, 3rd Edition, 1980)

Using nomograph, pipe diameter can be sized for turbulent flow ($N_{RE} > 2100$) or viscous flow ($N_{RE} < 2100$). While the expected flow would be turbulent, the nomograph was used to size pipes for both viscous and turbulent flow to see which flow condition resulted in the larger diameter. The pipe diameter selected was based on the flow condition that yielded the largest diameter.

RFW 10-05-003/A-5/85

WESTON MANAGERS DESIGNERS/CONSULTANTS

SHEET 2 of 4

CLIENT/SUBJECT RFP W.O. NO.

TASK DESCRIPTION Sizing of Piping for GW Conveyance TASK NO.

PREPARED BY BAH DEPT DATE

MATH CHECK BY DEPT DATE

METHOD REV. BY DEPT DATE

APPROVED BY

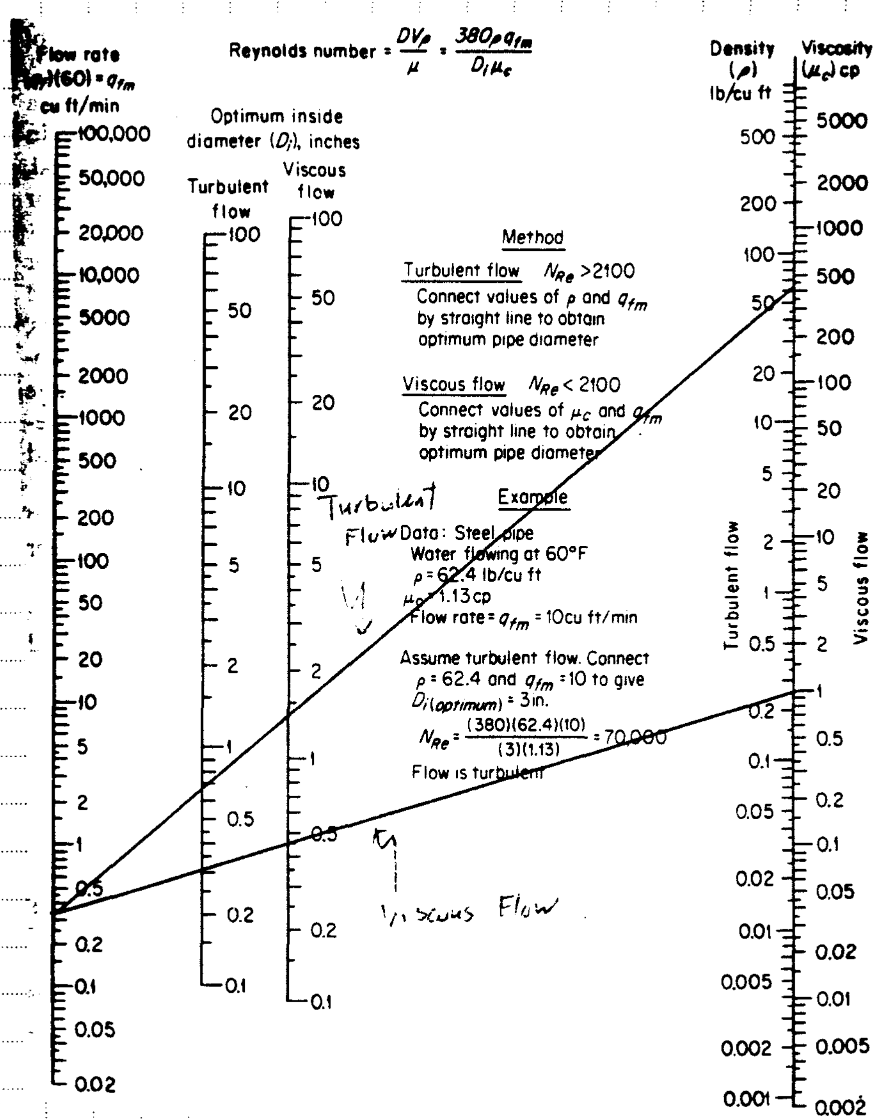
DEPT DATE

Numograph 1

For Pipe Segments from SV1 and SI1

Max Flow Rate = 2.5 gpm = 0.33 ft³/min

Density = 62.4 lb/ft³ Viscosity = 1 cp



Optimum Diameter Viscous Flow = 0.45"

Optimum Diameter Turbulent Flow = 0.7"

Selected Pipe Diameter = 0.75" (standard size)

WESTON
MANAGERS DESIGNERS/CONSULTANTS

SHEET 3 of 4

CLIENT/SUBJECT RFP W.O. NO.

TASK DESCRIPTION Sizing of Piping For GW Conveyance TASK NO.

PREPARED BY BAH DEPT DATE

MATH CHECK BY DEPT DATE

METHOD REV. BY DEPT DATE

APPROVED BY

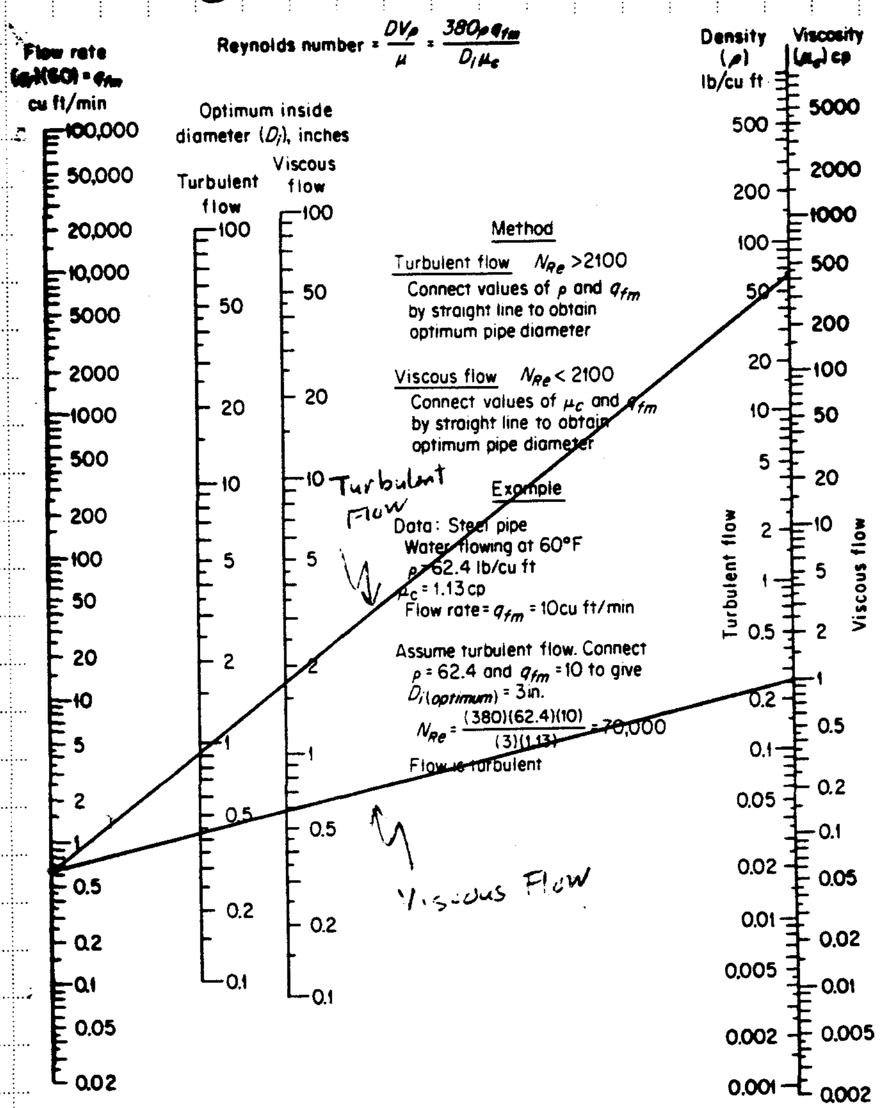
DEPT DATE

Nomograph 2

For Pipe Segments – combined flow from SV1 and SI1, flow from Knockdown Drum T-1

Max Flow Rate = 5 gpm = 0.67 ft³/min

Density = 62.4 lb/ft³ Viscosity = 1 cP



Optimal Diameter Viscous Flow = 0.6"

Optimal Diameter Turbulent Flow = 0.9"

Selected Pipe Diameter = 1.0" (Standard Size)

WESTON
MANAGERS DESIGNERS/CONSULTANTS

CLIENT/SUBJECT RFP W.O. NO.

TASK DESCRIPTION Sizing of Piping for GW Conveyance TASK NO.

PREPARED BY BAH DEPT DATE

MATH CHECK BY DEPT DATE

METHOD REV. BY DEPT DATE

APPROVED BY

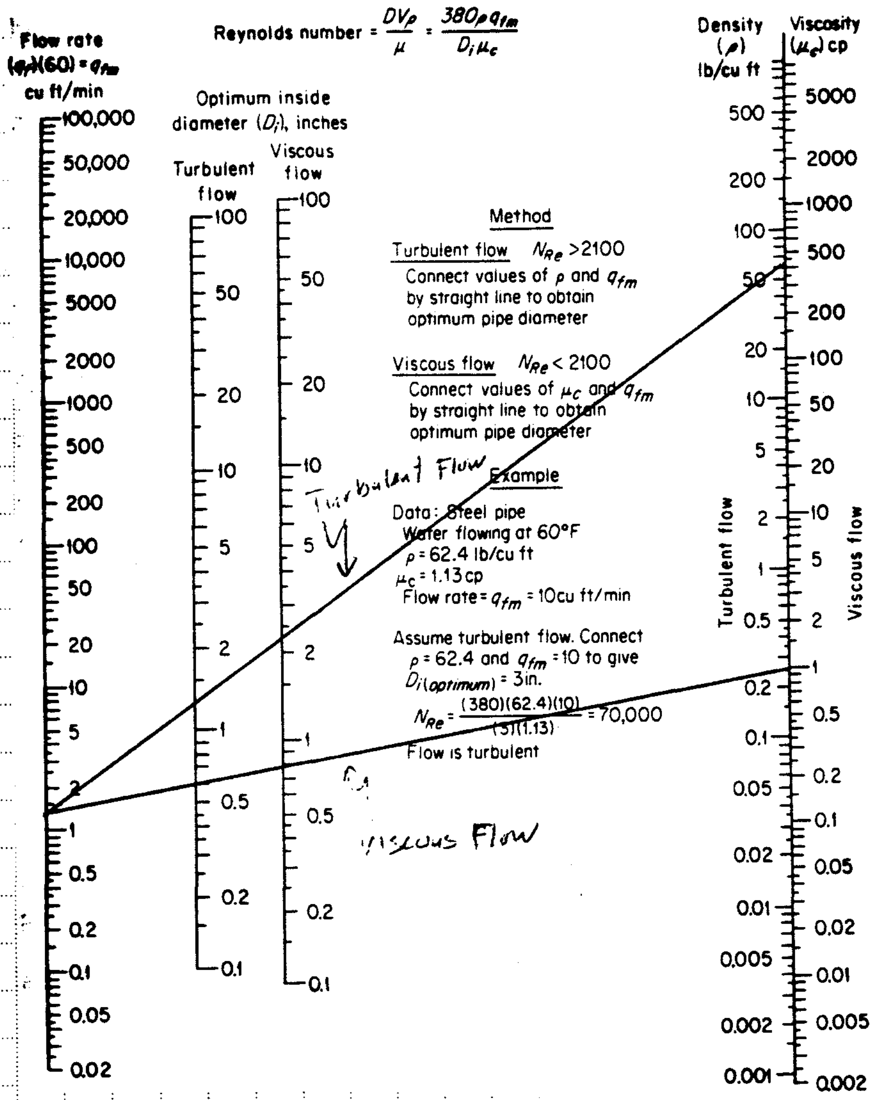
DEPT DATE

Nomograph 3

For Pipe Segment for Total Combined Flow

Max Flow Rate = 10 gpm = 1.34 ft^3/min

Density = 62.4 lb/ft^3 Viscosity = 1 cP



Optimal Diameter Viscous Flow = 0.8"

Optimal Diameter Turbulent Flow = 1.25"

Selected Pipe Diameter = 1.25" (Standard Size)

WESTON
MANAGERS DESIGNERS/CONSULTANTS

CLIENT/SUBJECT RFP W.O. NO.
TASK DESCRIPTION POWER REQUIREMENTS TASK NO.
PREPARED BY MFR DEPT DATE
MATH CHECK BY DEPT DATE
METHOD REV. BY DEPT DATE
APPROVED BY
DEPT DATE

PORTABLE GENERATOR SIZING

1. TRAILER

a. BLOWERS:

#	BHP*	HP
B-1	10	15
B-2	20	25
B-3	7.5	10

* Break Horsepower - Nominal HP required, use next size as safety factor

b. LIGHTING: 1kW

c. HEATING/COOLING: 2kW

d. INSTRUMENTATION: 2kW

e. ADD'L (MISC) EQUIPMENT (INCL. POWER FOR OUTLETS ON CONTROL PANEL): 5kW

2. HEAT TRACING:

General - All heat tracing calc's are based on guidelines presented in the "Thermon, Co. General Catalog." The following assumption were made:

1. All piping/tanks are insulating using 1" fiberglass.

CLIENT/SUBJECT ______ W.O. NO. ______

TASK DESCRIPTION ______ TASK NO. ______

PREPARED BY ______ DEPT ______ DATE ______

MATH CHECK BY ______ DEPT ______ DATE ______

METHOD REV. BY ______ DEPT ______ DATE ______

APPROVED BY ______ DEPT ______ DATE ______

PORTABLE GENERATOR SIZING (CONT'D)

2. All air manifold is 6"ϕ
3. All H_2O manifold is 1"ϕ
4. Storage tank measures 8'×8'×20', fully enclosed.

AIR:

$T_p = 50°F$ (pipe maintenance temp)
$T_a = 0°F$ (ambient temp)
$\phi = 6''$
$C_i = 0.137$ (conductance, from table)
$T_c = 0.9234$ (temp correction factor, from table)

$$\text{Heat Loss} = C_i (T_p - T_a) T_c$$

$$= 6.3 \text{ watts/ft.}$$

conservatively assume 100 ft of pipe:

Power = 630 watts $\Rightarrow$ $\boxed{1\text{kW}}$

WATER:

$T_p = 50°F$
$T_a = 0°F$
$\phi = 1''$
$C_i = 0.0381$
$T_c = 0.9234$

Heat Loss = $0.0381(50)(0.9234) = 1.75$ watts/ft

Assume 100 ft.

$\therefore$ 175 watts $\Rightarrow$ $\boxed{0.5\text{kW}}$

CLIENT/SUBJECT ______ W.O. NO. ______

TASK DESCRIPTION ______ TASK NO. ______

PREPARED BY ______ DEPT ______ DATE ______

MATH CHECK BY ______ DEPT ______ DATE ______

METHOD REV. BY ______ DEPT ______ DATE ______

APPROVED BY ______

DEPT ______ DATE ______

STORAGE TANK:

$SA = 2(8)(8) + 4(8)(20) = 768\ ft^2$

$T_p = 50°F$

$T_a = 0°F$

Heat Loss = 3.57 watts/ft^2 (from table)

$= (3.57)(768) = 2{,}741$ Watts

$\boxed{\Rightarrow 5kW}$ (Add'l wattage applied because of no tank top)

As indicated in the following pages, a 125kW (113kW nominal) generator may be required.

Based on conversations with the vendor, the fuel usage rate of this particular generator is:

$\boxed{5.9 \text{ gallons/hr}}$

Fuel tank sizes range from 50gal to 300gal.

NOTE: This is a rough estimate ONLY. The power requirements of the equipment utilized will vary.

ONAN CORPORATION
GenSize 2
Version 1.25

Project Name: (ROCKY FLATS ISV)
File Name: RFP2

Project Parameters

Duty..............: Stationary Prime
Voltage...........: 277/480 Y
Frequency.........: 60
Max. Temp. Rise...: 105
Max. VDIP%........: 22
Max. Altitude.....: 5100
Altitude Scale....: Feet
Max. Amb. Temp....: 100
Temperature Scale.: Fahrenheit
Cooling System....: Radiator
Fuel Type.........: Diesel

Load Listing

Load Number: 1 Load Type: Motor HP Entry Phase: 3

Load Name: (15) Output HP: 15
Comment: (BLOWER B-1)

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:
44.3	90.0	78.4	0.49	12.9	14.7	7.0	0.88

Load Number: 2 Load Type: Motor HP Entry Phase: 3

Load Name: (25) Output HP: 25
Comment: (BLOWER B-2)

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:
66.0	150.0	134.7	0.44	21.3	24.0	11.0	0.89

Load Number: 3 Load Type: Motor HP Entry Phase: 3

Load Name: (10) Output HP: 10
Comment: (BLOWER B-3)

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:
36.3	68.0	57.5	0.53	8.7	10.0	5.0	0.87

Load Number: 4 Load Type: Resistive Phase: 1

Load Name: (GENERAL) Input KW: 16.5
Comment: (ALL OTHER EQUIPMENT)

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:

16.5	16.5	0.0	1.00	16.5	16.5	0.0	1.00

Step Sequence/Load

Step Number: 1 Surge KW: 110 Surge SKVA: 240

Step Name: START NEGATIVE PRESSURE
Comment: B-1 AND B-2

Load #	Qty	SKW	SKVA	SKVAR	SPF	RKW	RKVA	RKVAR	RPF
1	1	44.3	90.0	78.4	0.49	12.9	14.7	7.0	0.88
2	1	66.0	150.0	134.7	0.44	21.3	24.0	11.0	0.89
Step Total:		110.3	240.0	213.1	0.46	34.2	38.7	18.1	0.88

Step Number: 2 Surge KW: 71 Surge SKVA: 68

Step Name: AIR INJECTION
Comment:

Load #	Qty	SKW	SKVA	SKVAR	SPF	RKW	RKVA	RKVAR	RPF
3	1	36.3	68.0	57.5	0.53	8.7	10.0	5.0	0.87
Step Total:		36.3	68.0	57.5	0.53	8.7	10.0	5.0	0.87

Step Number: 3 Surge KW: 59 Surge SKVA: 17

Step Name: OTHER
Comment:

Load #	Qty	SKW	SKVA	SKVAR	SPF	RKW	RKVA	RKVAR	RPF
4	1	16.5	16.5	0.0	1.00	16.5	16.5	0.0	1.00
Step Total:		16.5	16.5	0.0	1.00	16.5	16.5	0.0	1.00

ONAN CORPORATION GENSIZE 2

--R U N N I N G------			-----M A X----S U R G E--At Specified Voltage---			
KW	KVA	PF	KW	Occurs in Step	KVA	Occurs in Step
59	65	0.91	110	1	240	1

Recommended GenSet GenSet Voltage: 208-240/416-480
Model: 125DGEA

Nominal KW	Duty	Specified Voltage	Freq.	Alternator Temp. Rise Specified	Alternator Temp. Rise Recommended
113	Prime	277/480 Y	60	105	105

When operated at 5100 Feet Altitude
and 100 degrees F Ambient the
operating performance is:
* GenSet selected with one GenSet. *

Maximum KW	Voltage Dip	Freq. Dip	Excitation
113	21%	6%	Shunt

Onan Corporation has developed this GenSize 2 computer program to help you, the engineer, with a generator set selection. The recommendations are based upon your input of the genset requirements and typical performance data published by NEMA and other agencies.

Due to changing load and site conditions beyond our control, we cannot be certain the selection of a genset based upon the recommendation of this computer program will meet the site requirements. Therefore, nothing in this program may be construed as a warranty. You must decide for yourself or consult with your local Cummins/Onan distributor that the generator set selected is sufficient for your intended purpose. Each Onan Corporation generator set is covered by an express written warranty which is in lieu of of all other warranties, expressed or implied.

Please consult with your Cummins/Onan distributor representative in your area for further information.

WESTON
MANAGERS DESIGNERS/CONSULTANTS

SHEET 1 of 2

CLIENT/SUBJECT EG&G - Rocky Flats, Inc. W.O. NO. 2029-37-01
TASK DESCRIPTION SVE Pilot Test Plan TASK NO. 0130
PREPARED BY RMC DEPT 649 DATE 12/30/92
MATH CHECK BY ______ DEPT ______ DATE ______
METHOD REV. BY ______ DEPT ______ DATE ______

APPROVED BY M. Kress (by Phone)
DEPT ______ DATE 12/31/92

Purpose: Estimate mass of VOCs recovered per 24 hours of SVE unit operation corresponding to an average VOC concentration of 10 ppm V.

Method: Ideal gas equation of state.

Assumptions:

SVE operational parameters

Q = Process vapor flow[1] = 300 ft^3/min
= 432,000 ft^3/day

T = vapor temperature = 60°F
= 520°R

P = Process vacuum = 15 in Hg (vacuum)
= 14.9 in Hg (absolute)

Constants and contaminant property data

R = Universal gas constant = 21.85 $\frac{\text{in Hg} \cdot ft^3}{\text{lbmols} \cdot °R}$

MW_{AVG} = Average molecular weight of CCl_4, TCE, and PCE = 149 $\frac{lbm}{lbmol}$

Results:

10 ppmV of VOCs in extracted vapors corresponds to 4.32 ft^3/day of VOCs based on Q = 432,000 ft^3/day.

RFW 10-05-003/A-5/85

WESTON MANAGERS DESIGNERS/CONSULTANTS

SHEET 2 of 2

CLIENT/SUBJECT EG&G - Rocky Flats, Inc. W.O. NO. 2029-37-01

TASK DESCRIPTION TASK NO. 0130

PREPARED BY RMC DEPT 649 DATE 12/30/92

MATH CHECK BY DEPT DATE

METHOD REV. BY DEPT DATE

APPROVED BY M. Kress (by Phone) DEPT DATE 12/31/92

$PV = nRT$ (Idal Gas Equation of State)

$$n = \frac{PV}{RT} = \frac{(14.9 \text{ in Hg})(4.32 \text{ ft}^3 \text{ of VOCs/day})}{\left(21.85 \frac{\text{in Hg} \cdot \text{ft}^3}{\text{lbmols} \cdot {}^\circ R}\right)(520\ {}^\circ R)}$$

$$n = 0.00567 \ \frac{\text{lbmols of VOCs}}{\text{day}}$$

M = mass of VOCs recovered per day

$$= n * MW_{avg}$$

$$= 0.00567 \ \frac{\text{lbmols of VOCs}}{\text{day}} * 149 \ \frac{\text{lbm}}{\text{lbmols}}$$

$$= 0.84 \ \frac{\text{lbm of VOCs}}{\text{day}}$$

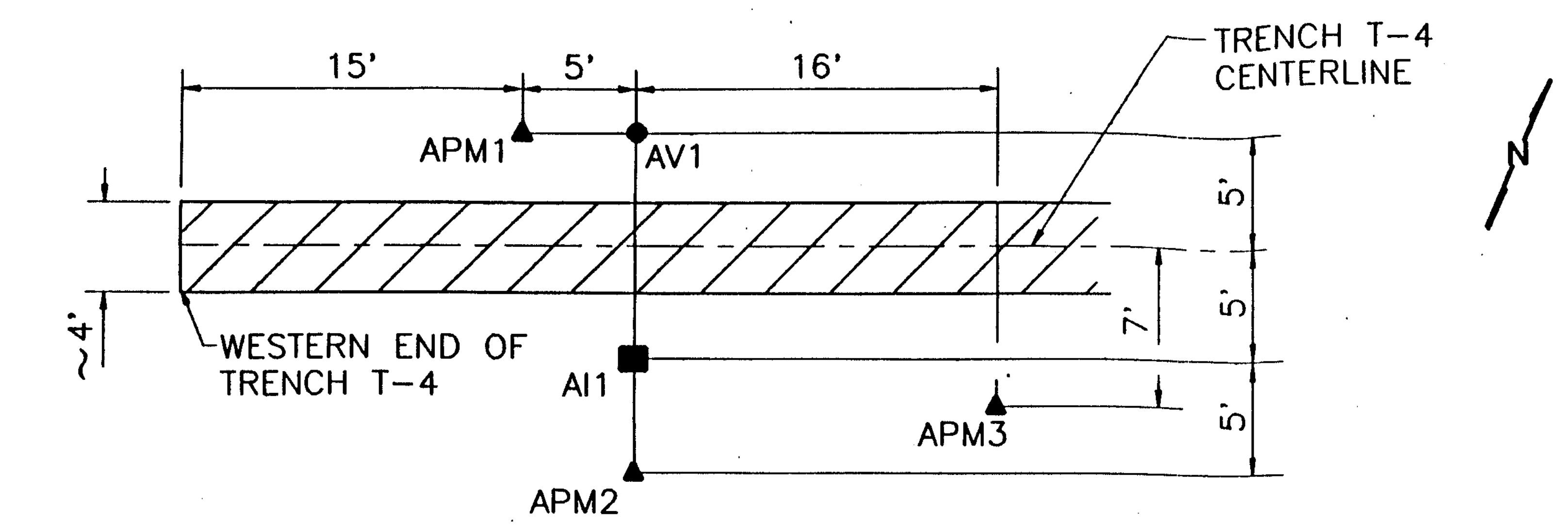
or approximately **1 lbm of VOCs/day**

1 SVE pilot unit is designed to operate up to 600 ft³/min. 300 ft³/min of actual flow is assumed for this calculation.

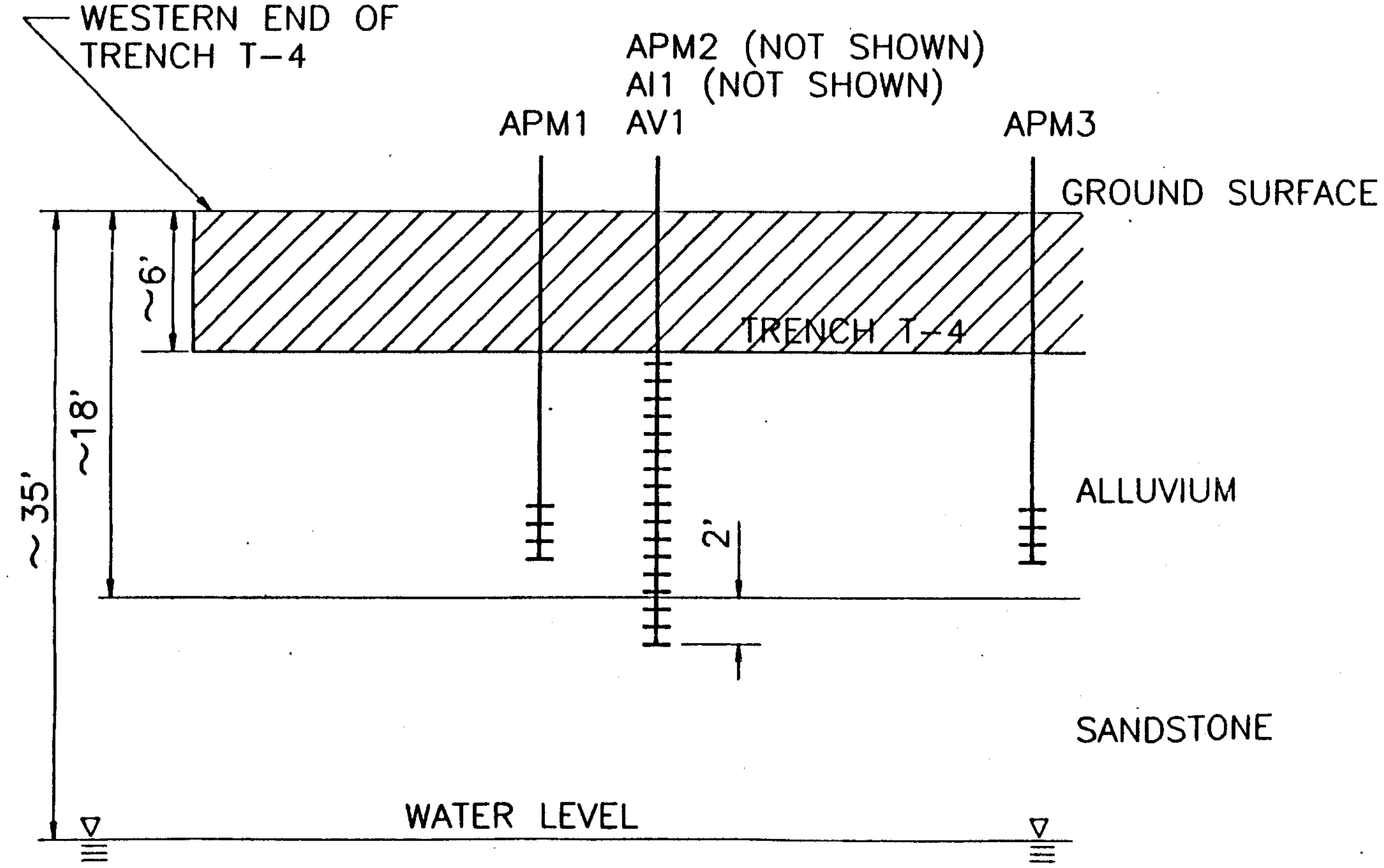
Appendix F

Rocky Flats Plant Standard Operating Procedures Applicable to the Subsurface IM/IRA Pilot Test Program

Procedure No.	Title
FO.03	General Equipment Decontamination
FO.04	Heavy Equipment Decontamination
FO.05	Handling of Purged and Developed Water
FO.06	Handling of Decontamination Water and Wash Water
FO.07	Handling of Personal Protective Equipment
FO.08	Handling of Drilling Fluids and Cuttings
FO.09	Handling of Residual Samples
FO.12	Decontamination Facility Operations
FO.13	Containerizing, Preserving, Handling and Shipping of Soil and Water Samples
FO.15	Photoionization Detectors (PID) and Flare Ionization Detectors (FID)
FO.17	Land Surveying
FO.18	Environmental Sampling Radioactivity Content Screening
GT.01	Logging Alluvial and Bedrock Material
GT.02	Drilling and Sampling Using Hollow Stem Auger Techniques
GT.03	Isolating Bedrock from Alluvium with Grouted Surface Casing
GW.02	Well Development



PLAN VIEW



EAST/WEST CROSS-SECTION

N.T.S. (HORIZ. DIMENSION IS EXAGGERATED)

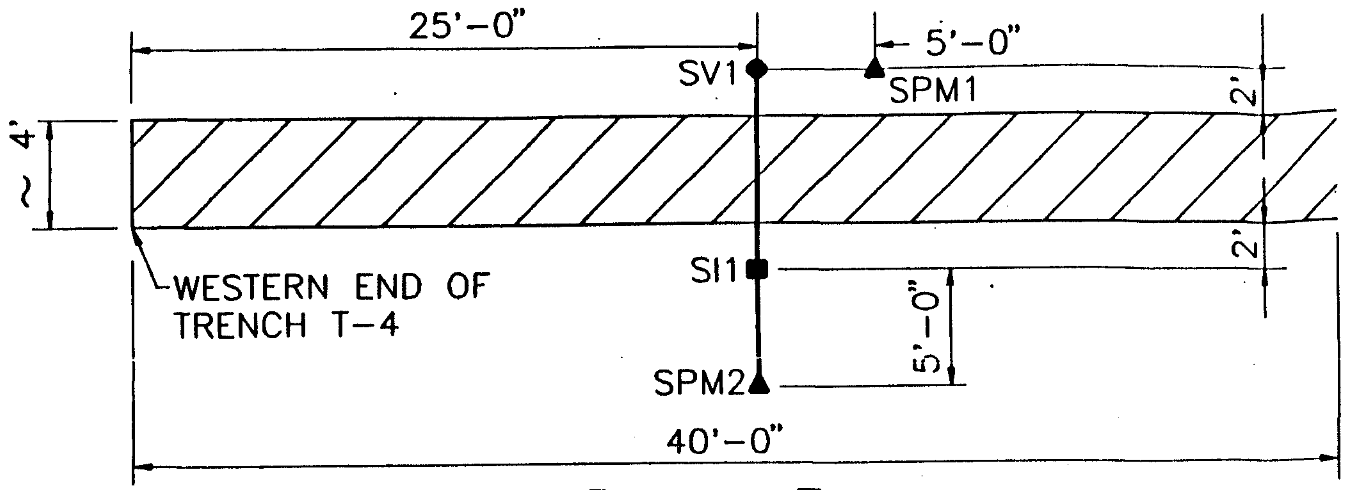
- ● VERTICAL EXTRACTION VENT
- ▲ PRESSURE MONITORING (PM) PROBE/ PASSIVE AIR INLET
- ■ AIR INJECTION VENT

PM PROBE	DISTANCE FROM AV1 (ft.)
APM1	5
AI1	10
APM2	15
APM3	20

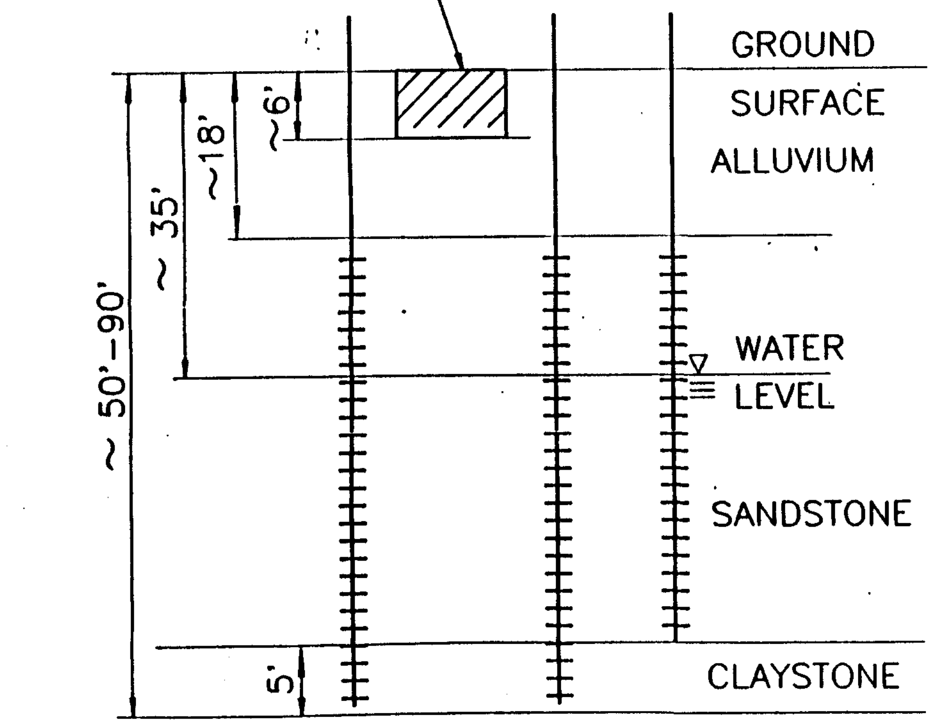
VENT/ PROBE	SCREENED INTERVAL DEPTH (ft. BGS)
AV1	~ 9–20
AI1	~ 9–18
APM1	~ 13–16
APM2	~ 13–16
APM3	~ 13–16

(DEPENDENT UPON GEOLOGY ENCOUNTERED)

KEYWORDS	ISSUE	DESCRIPTION		DATE	RFP	DOE	CLASS	JOB NO.
1.		BY	DATE	U. S. DEPARTMENT OF ENERGY				
2.	DESIGNED	M. KRESS	8/31/92	ROCKY FLATS AREA OFFICE		GOLDEN, COLORADO		
3.	DRAWN	SCB	8/18/92	ROCKY FLATS PLANT GOLDEN, COLORADO 80402-0464				
4.	CHECKED							
5.	APPROVED			SUBSURFACE IM/IRA EAST TRENCHES AREA ALLUVIUM VAPOR EXTRACTION DESIGN				
BLDG./FACILITY								
ROOM/AREA								
GRID COORD./COL NO.	SUBMITTED			SIZE	DRAWING NUMBER	ISSUE	SHEET	
MASTER YES ☐ NO ☐	APPROVED RFP			B			1 OF 11	
	APPROVED DOE							



PLAN VIEW



NORTH/SOUTH CROSS-SECTION

N.T.S. (HORIZ. DIMENSIONS EXAGGERATED)

N

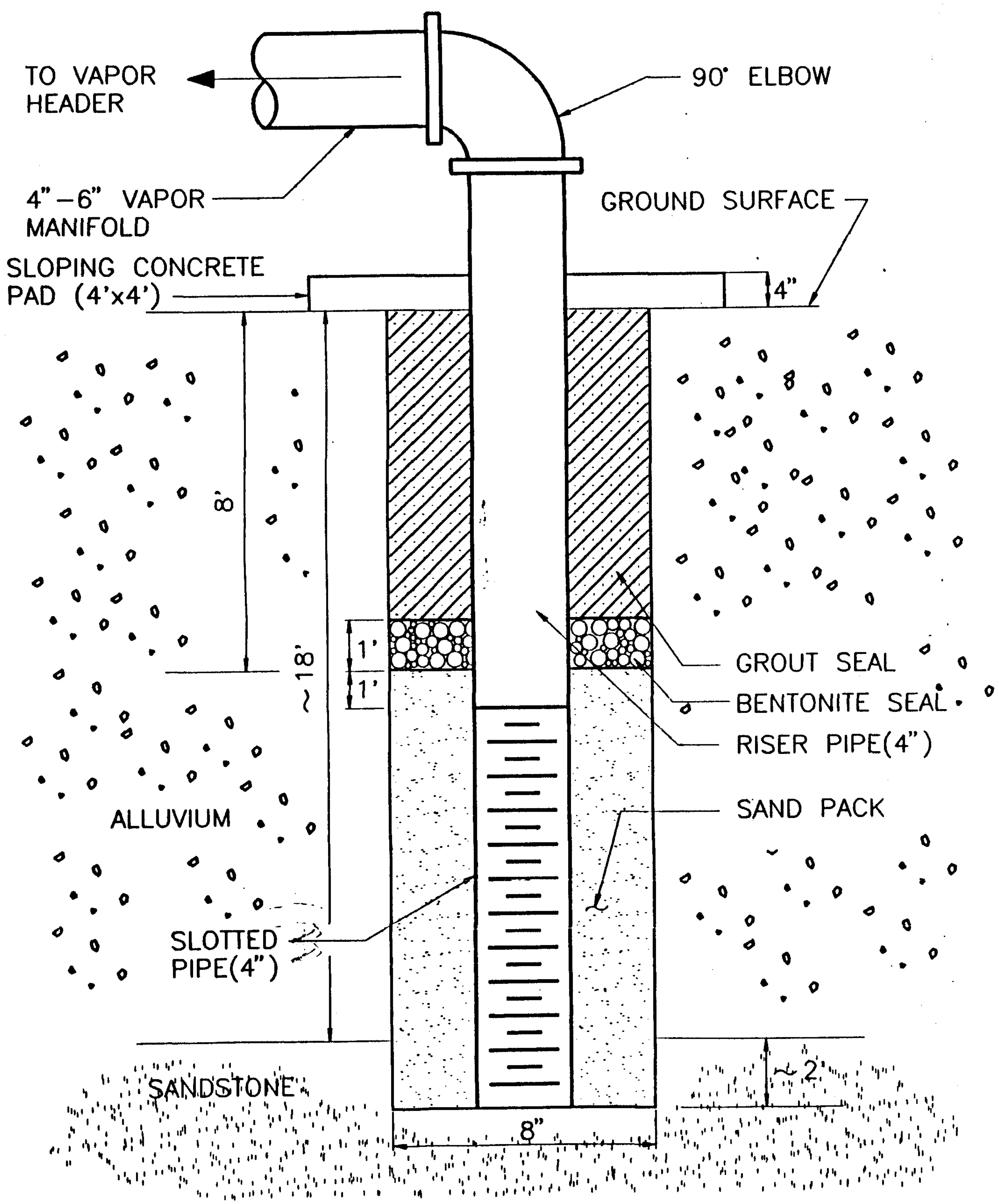
- ● VERTICAL EXTRACTION VENT/GROUNDWATER EXTRACTION WELL
- ▲ PRESSURE MONITORING (PM) PROBE/ PASSIVE AIR INLET
- ■ AIR INJECTION VENT/ GROUNDWATER EXTRACTION WELL

AIR INJECTION WELL/PROBE	DISTANCE FROM SV1 (ft.)
SI1	6–8
SPM1	5
SPM2	11–13

VENT/ PROBE	SCREENED INTERVAL DEPTH (ft. BGS)
SV1	~ 22–90 (MAX)
SI1	~ 22–90 (MAX)
SPM1	~ 22–90 (MAX)
SPM2	~ 22–90 (MAX)

(DEPENDENT UPON GEOLOGY ENCOUNTERED)

KEYWORDS	ISSUE	DESCRIPTION		DATE	RFP	DOE	CLASS	JOB NO.
1.		BY	DATE	U. S. DEPARTMENT OF ENERGY				
2.	DESIGNED	M. KRESS	8/31/92	ROCKY FLATS AREA OFFICE		GOLDEN, COLORADO		
3.	DRAWN	SCB	8/18/92	ROCKY FLATS PLANT				
4.	CHECKED			GOLDEN, COLORADO 80402-0464				
5.	APPROVED			SUBSURFACE IM/IRA				
BLDG./FACILITY				EAST TRENCHES AREA				
ROOM/AREA				SANDSTONE VAPOR EXTRACTION DESIGN				
GRID COORD./COL NO.	SUBMITTED			SIZE	DRAWING NUMBER		ISSUE	SHEET
MASTER YES ☐ NO ☐	APPROVED RFP			B				2 OF 11
	APPROVED DOE							



KEYWORDS	ISSUE	DESCRIPTION		
1.			BY	DATE
2.	DESIGNED		M. KRESS	8/31/92
3.	DRAWN		MH	8/10/92
4.	CHECKED			
5.	APPROVED			
BLDG./FACILITY				
ROOM/AREA				
GRID COORD./COL NO.	SUBMITTED			
MASTER	APPROVED RFP			
YES ☐ NO ☐	APPROVED DOE			

DATE	RFP	DOE	CLASS	JOB NO.

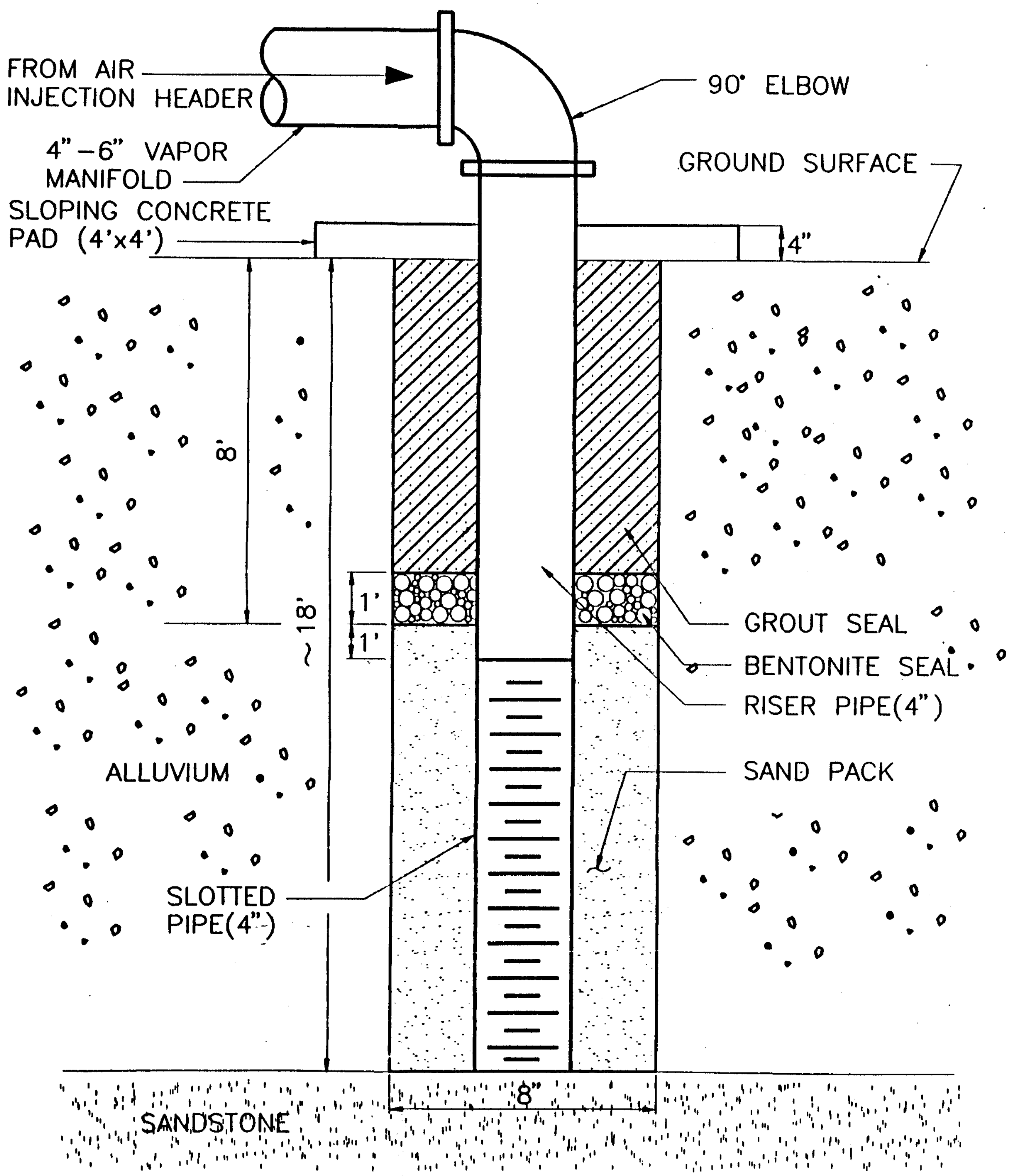
U. S. DEPARTMENT OF ENERGY

ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

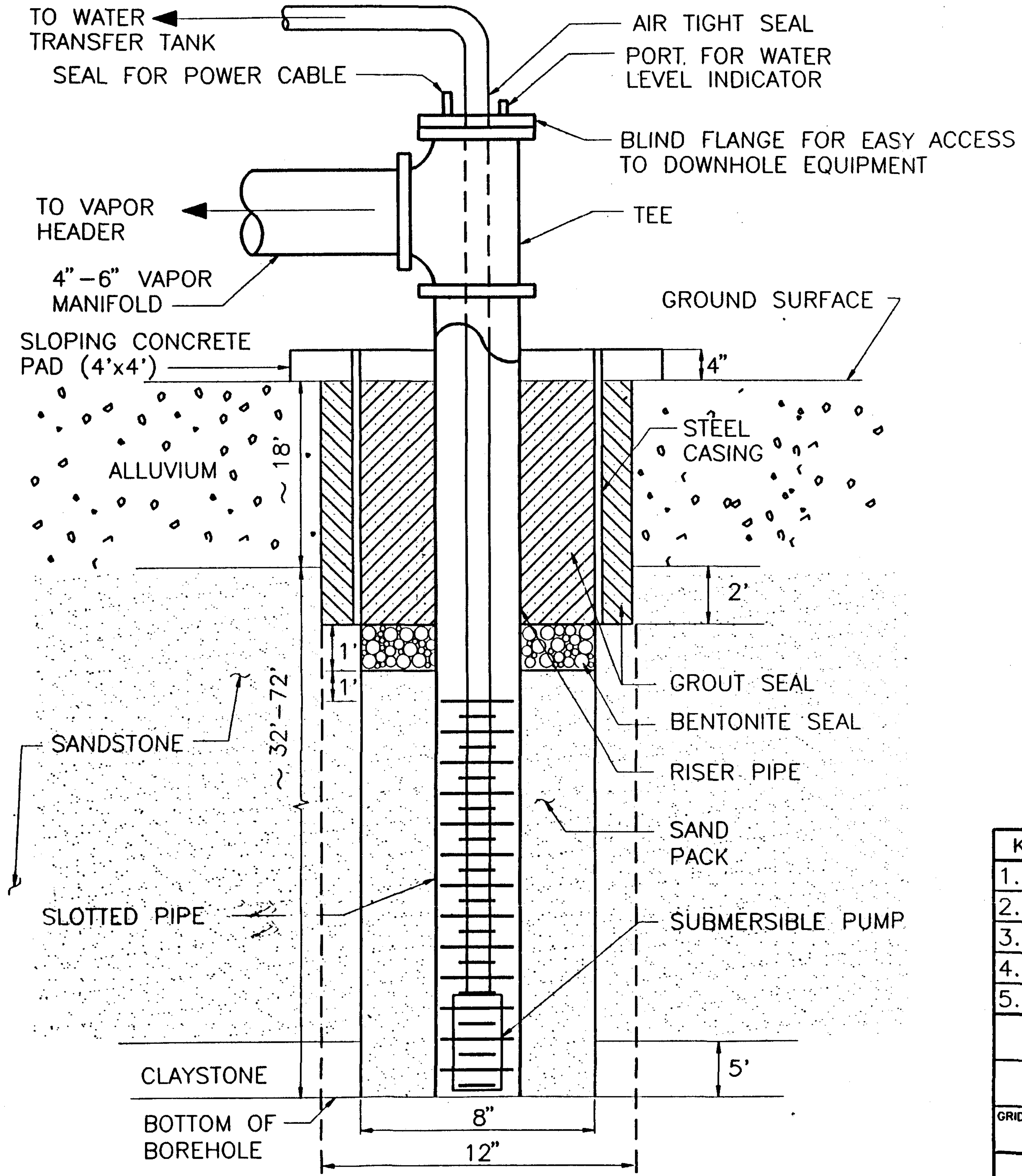
ROCKY FLATS PLANT
GOLDEN, COLORADO 80402-0464

SUBSURFACE IM/IRA
EAST TRENCHES AREA
ALLUVIAL VENT CONSTRUCTION

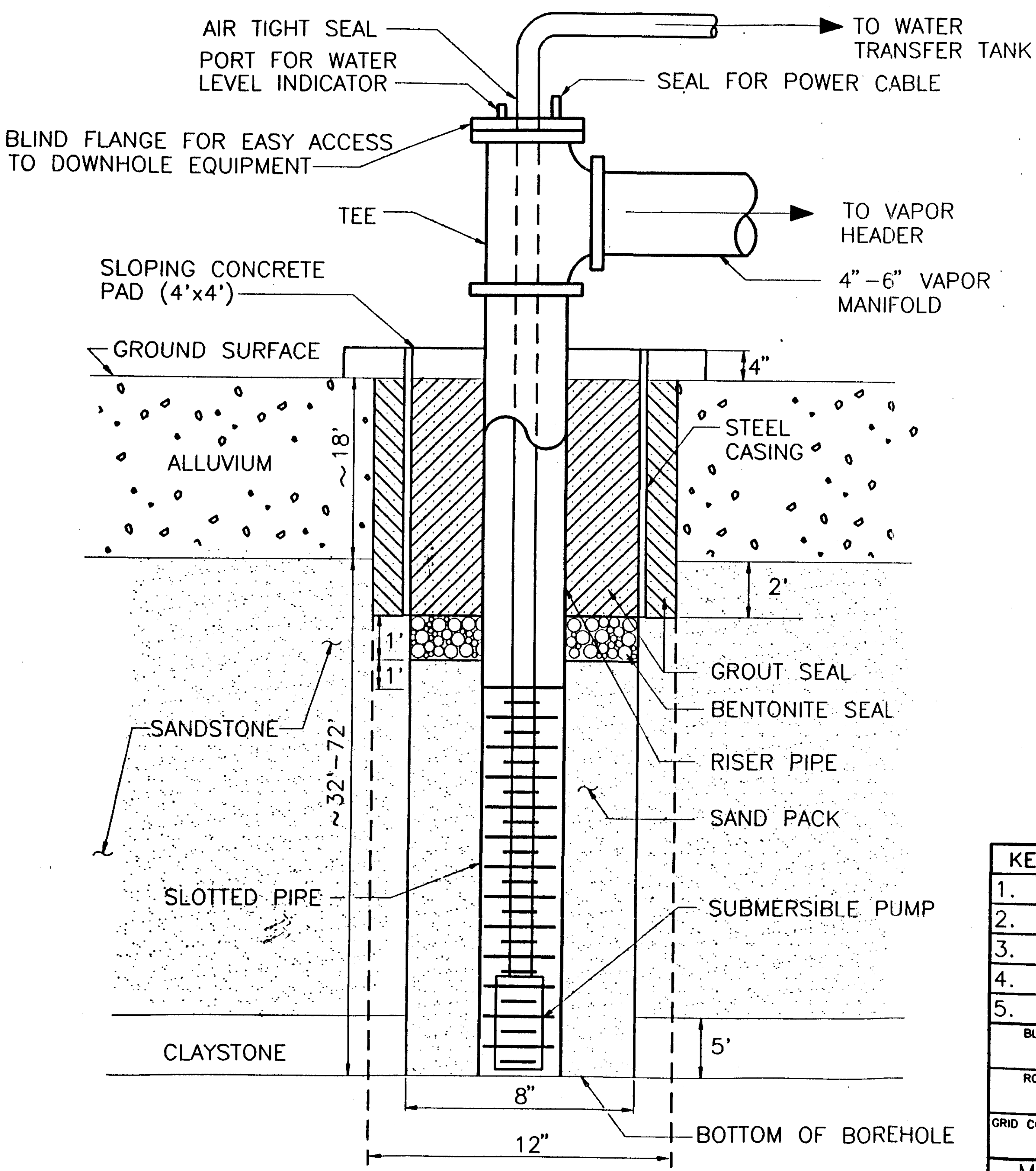
SIZE	DRAWING NUMBER	ISSUE	SHEET
B			3 OF 11



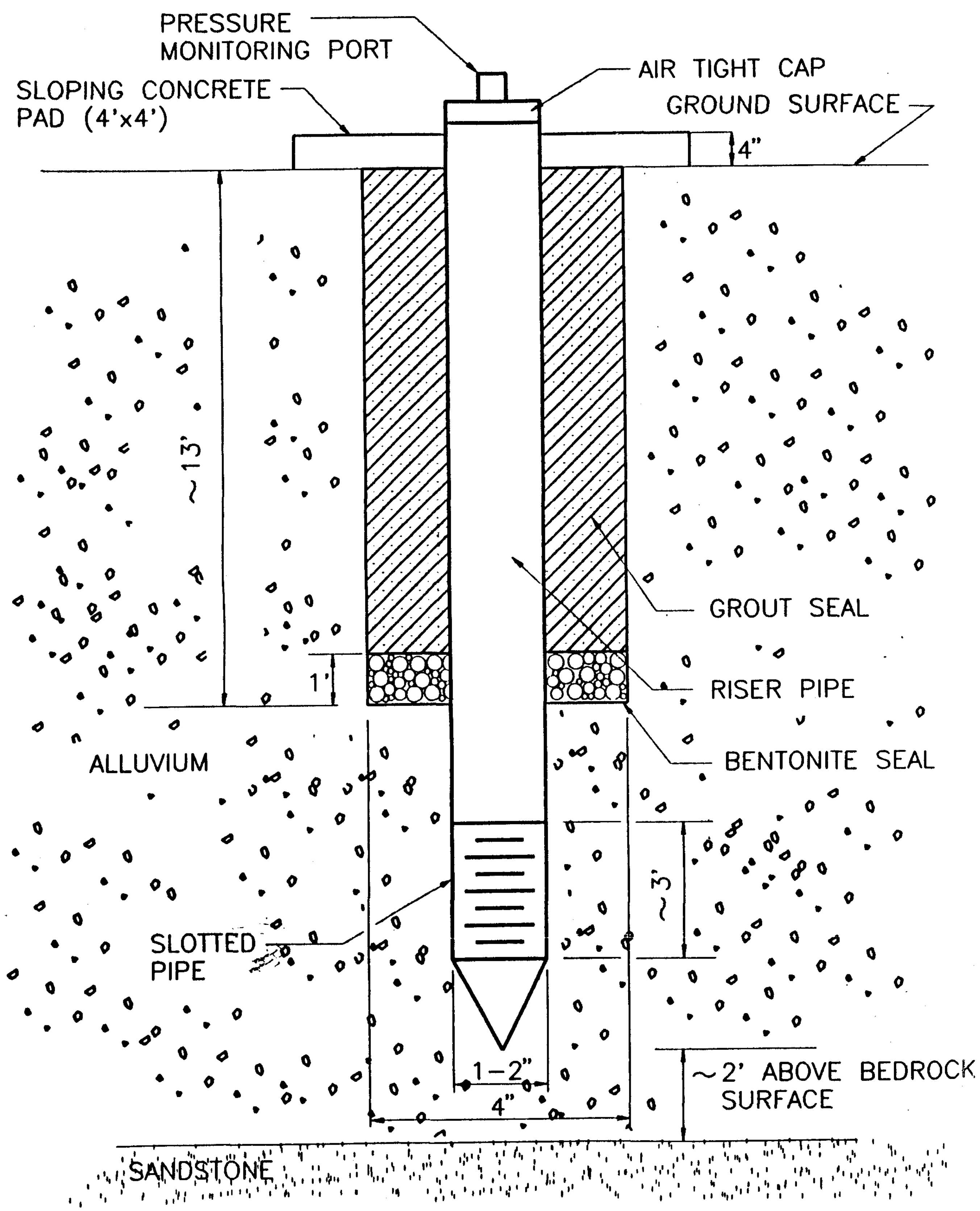
KEYWORDS	ISSUE	DESCRIPTION		DATE	RFP	DOE	CLASS	JOB NO.
1.		BY	DATE	U. S. DEPARTMENT OF ENERGY				
2.	DESIGNED	M. KRESS	8/31/92	ROCKY F'ATS AREA OFFICE		GOLDEN, COLORADO		
3.	DRAWN	MH	8/10/92	ROCKY FLATS PLANT GOLDEN, COLORADO 80402-0464				
4.	CHECKED							
5.	APPROVED			SUBSURFACE IM/IRA EAST TRENCHES AREA ALLUVIUM AIR INJECTION VENT				
BLDG./FACILITY								
ROOM/AREA								
GRID COORD./COL NO.	SUBMITTED			SIZE	DRAWING NUMBER		ISSUE	SHEET
MASTER YES ☐ NO ☐	APPROVED RFP			B				4 OF 11
	APPROVED DOE							



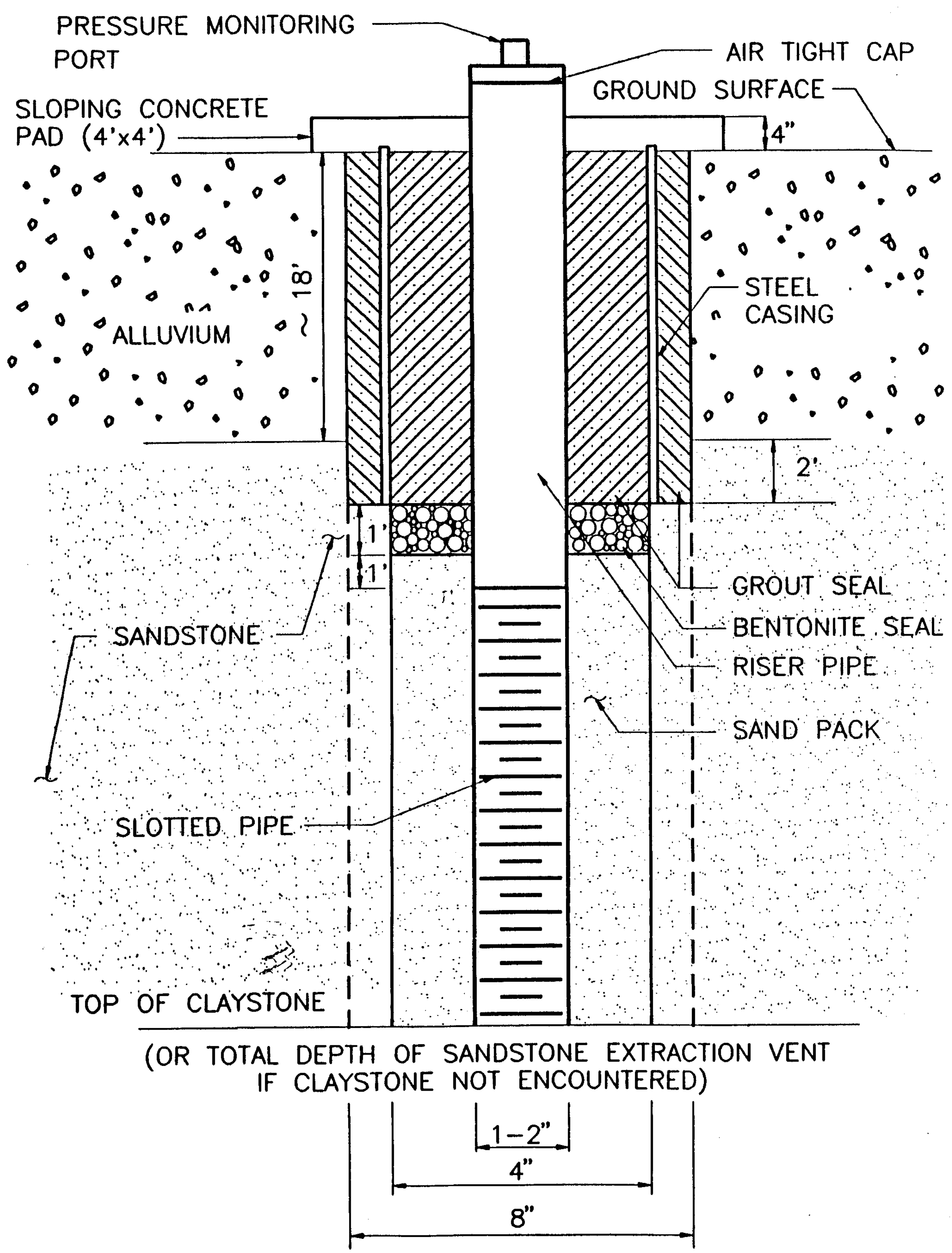
KEYWORDS	ISSUE	DESCRIPTION		DATE	RFP	DOE	CLASS	JOB NO.
1.		BY	DATE	U. S. DEPARTMENT OF ENERGY				
2.	DESIGNED	M. KRESS	8/31/92	ROCKY FLATS AREA OFFICE			GOLDEN, COLORADO	
3.	DRAWN	MH	8/10/92	ROCKY FLATS PLANT GOLDEN, COLORADO 80402-0464				
4.	CHECKED							
5.	APPROVED							
BLDG./FACILITY				SUBSURFACE IM/IRA EAST TRENCHES AREA SANDSTONE VENT CONSTRUCTION				
ROOM/AREA								
GRID COORD./COL NO.	SUBMITTED			SIZE	DRAWING NUMBER		ISSUE	SHEET
MASTER YES ☐ NO ☐	APPROVED RFP			B				5 OF 11
	APPROVED DOE							



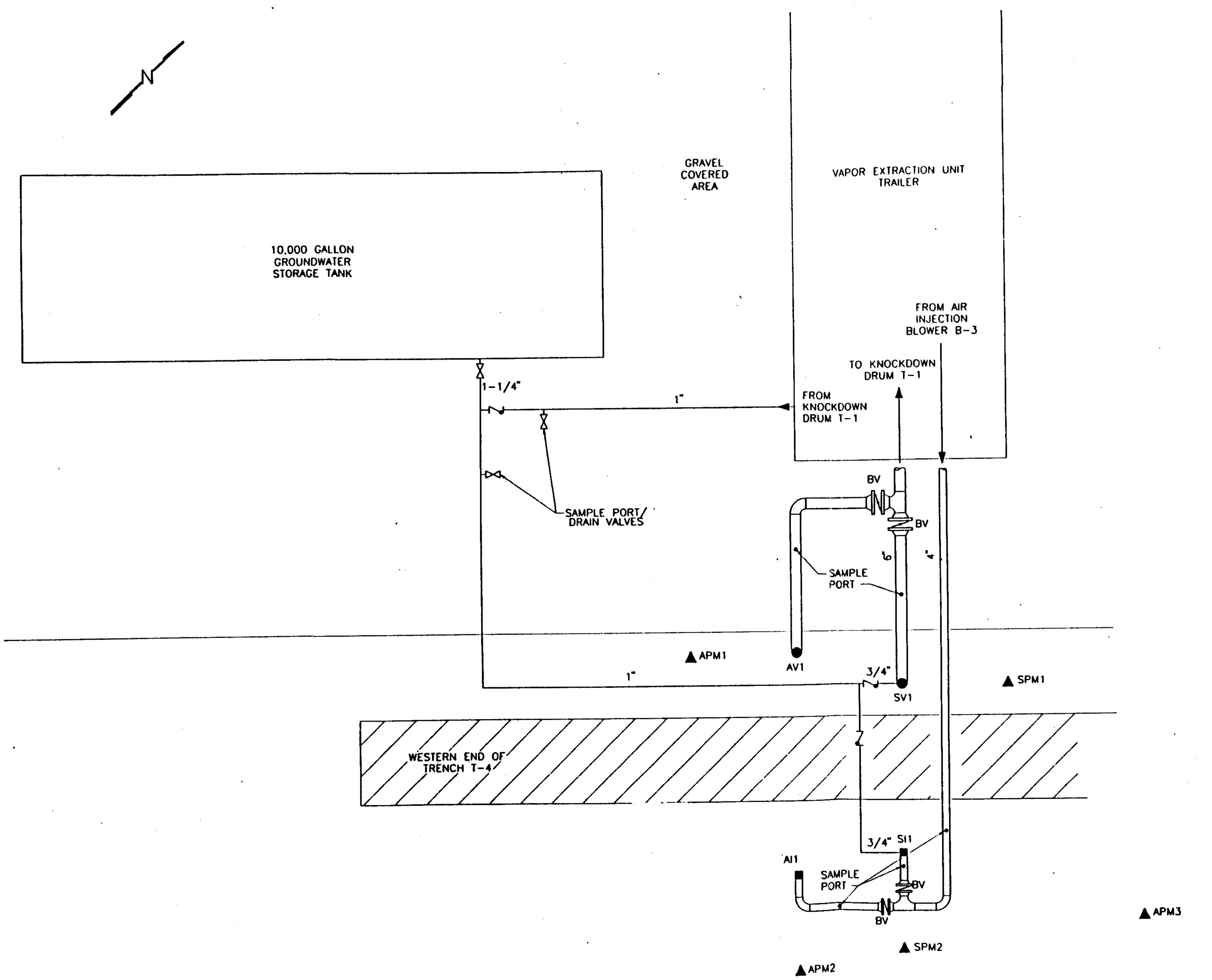
KEYWORDS	ISSUE	DESCRIPTION		DATE	RFP	DOE	CLASS	JOB NO.
1.		BY	DATE	U. S. DEPARTMENT OF ENERGY				
2.	DESIGNED	M. KRESS	8/31/92	ROCKY FLATS AREA OFFICE — GOLDEN, COLORADO				
3.	DRAWN	MH	8/10/92	ROCKY FLATS PLANT, GOLDEN, COLORADO 80402-0464				
4.	CHECKED							
5.	APPROVED			SUBSURFACE IM/IRA EAST TRENCHES AREA SANDSTONE AIR INJECTION VENT				
BLDG./FACILITY								
ROOM/AREA								
GRID COORD./COL NO.	SUBMITTED			SIZE	DRAWING NUMBER		ISSUE	SHEET
MASTER YES ☐ NO ☐	APPROVED RFP			B				6 OF 11
	APPROVED DOE							



KEYWORDS	ISSUE	DESCRIPTION		DATE	RFP	DOE	CLASS	JOB NO.
1.		BY	DATE	U. S. DEPARTMENT OF ENERGY				
2.	DESIGNED	M. KRESS	8/31/92	ROCKY FLATS AREA OFFICE				GOLDEN, COLORADO
3.	DRAWN	MH	8/10/92	ROCKY FLATS PLANT GOLDEN, COLORADO 80402-0464				
4.	CHECKED							
5.	APPROVED			SUBSURFACE IM/IRA EAST TRENCHES AREA ALLUVIAL PRESSURE MONITORING PROBE				
BLDG./FACILITY								
ROOM/AREA								
GRID COORD./COL NO.	SUBMITTED			SIZE	DRAWING NUMBER		ISSUE	SHEET
MASTER YES ☐ NO ☐	APPROVED RFP			B				7 OF 11
	APPROVED DOE							



KEYWORDS	ISSUE	DESCRIPTION		DATE	RFP	DOE	CLASS	JOB NO.
1.		BY	DATE	U. S. DEPARTMENT OF ENERGY				
2.	DESIGNED	M. KRESS	8/31/92	ROCKY FLATS AREA OFFICE — GOLDEN, COLORADO				
3.	DRAWN	MH	8/10/92	ROCKY FLATS PLANT GOLDEN, COLORADO 80402-0464				
4.	CHECKED							
5.	APPROVED			SUBSURFACE IM/IRA EAST TRENCHES AREA SANDSTONE PRESSURE MONITORING PROBE				
BLDG./FACILITY								
ROOM/AREA								
GRID COORD./COL NO.	SUBMITTED			SIZE	DRAWING NUMBER	ISSUE	SHEET	
MASTER YES ☐ NO ☐	APPROVED RFP			B			8 of 11	
	APPROVED DOE							



NOTE:

ALL MEASUREMENTS TAKEN AT SAMPLE PORTS WILL UTILIZE PORTABLE (I.E NOT IN-LINE) INSTRUMENTS.

LEGEND

- ● VAPOR EXTRACTION VENT/GROUNDWATER EXTRACTION WELL
- ▲ PRESSURE MONITORING PROBE
- ■ FORCED AIR INJECTION VENT/GROUNDWATER EXTRACTION WELL

0 2'-0" 4'-0" 6'-0" 8'-0"

3/8" = 1'0"

KEYWORDS
1.
2.
3.
4.
5.

	BY	DATE
DESIGNED	M. KRESS	10/20/92
DRAWN	A. MITCHEL	10/20/92
CHECKED	M. CORBIN	10/20/92
APPROVED	S. CISNEROZ	10/20/92

U. S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

ROCKY FLATS PLANT
GOLDEN, COLORADO 80402-0464

SUBSURFACE IM/IRA
EAST TRENCHES AREA
VAPOR MANIFOLD & PIPING LAYOUT

SIZE	DRAWING NUMBER	ISSUE	SHEET
D	9		9 of 11

MASTER YES ☐ NO ☐

PLOTTED 10/21/92 10:40 am
PLT. SC. 1=32 FILE NO.

9/92 3:53 pm

LINES

- OPEN CHANNEL
- PROCESS LINE
- AUXILIARY AND UTILITY LINES
- ELECTRICAL LINE
- CAPILLARY LINE
- PNEUMATIC INSTRUMENT LINE
- HYDRAULIC LINE
- SONIC OR RADIATION SIGNAL
- SOFTWARE LINK
- -BG- PROCESS LINE - BELOW GRADE

VALVE BODIES

- GATE VALVE
- GLOBE VALVE
- GLOBE VALVE W/PLUG TYPE DISC
- BALL VALVE
- VEE BALL VALVE
- PLUG VALVE (E=ECCENTRIC)
- NEEDLE VALVE
- KNIFE GATE VALVE
- BUTTERFLY VALVE
- PINCH VALVE
- DIAPHRAGM VALVE
- 3 WAY VALVE
- SWING CHECK VALVE
- SIGHT FLOW CHECK VALVE
- WAFER CHECK VALVE
- BALL CHECK VALVE
- CUSHIONED SWING CHECK VALVE
- PRESSURE SAFETY (RELIEF) VALVE
- RUPTURE DISC (PRESSURE)
- AIR RELEASE VALVE (CONSERVATION VENT)
- PRESSURE REDUCING OR REGULATING VALVE
- BACK PRESSURE VALVE
- FLAP VALVE
- FLOAT CONTROL VALVE
- MUD DRAIN VALVE
- PET COCK VALVE
- TELESCOPING VALVE (WITH OPERATOR)
- FLUSH BOTTOM VALVE

NOTE: ALL VALVE BODIES ARE LINE SIZE UNLESS OTHERWISE NOTED.

PIPING

- FLEXIBLE CONNECTION
- QUICK DISCONNECT COUPLING
- STRAINER "Y" TYPE
- EDUCTOR OR EJECTOR
- CONCENTRIC REDUCER
- ECCENTRIC REDUCER
- HOSE CONNECTION
- BLIND FLANGE
- FLANGE CONNECTION
- EQUIPMENT INSULATED
- EQUIPMENT HEAT TRACED AND INSULATED
- DRAIN
- EXPANSION JOINT
- FLANGED ADAPTER
- COUPLING
- INSULATED
- HEAT TRACED AND INSULATED
- PIPE UNION
- SHOCK ABSORBER OR SURGE SUPPRESSOR
- LINE CAP
- DOUBLE BASKET STRAINER

GATES

- DAMPER
- STOP PLATE
- SLUICE GATE
- ROTARY LOCK
- SLIDE GATE

AIR MOVING EQUIPMENT

- CENTRIFUGAL COMPRESSOR
- RECIPROCATING COMPRESSOR
- ROTARY COMPRESSOR
- POSITIVE DISPLACEMENT BLOWER
- FAN (CENTRIFUGAL)
- FAN (AXIAL)
- VACUUM PUMP
- AIR FILTER

PUMPS

- SUBMERSIBLE PUMP
- CENTRIFUGAL PUMP
- METERING PUMP
- PA — AIR DIAPHRAGM PUMP
- DIAPHRAGM PUMP (ELECTRIC)
- PROGRESSIVE CAVITY PUMP
- PISTON PUMP
- SCREW PUMP
- VERTICAL CENTRIFUGAL PUMP
- VERTICAL TURBINE PUMP

SPECIAL EQUIPMENT

- SCREW CONVEYOR
- FILTER
- BACK FLOW PREVENTER
- COMMINUTOR
- VARIABLE SPEED EXAMPLES:
  - VARIABLE SPEED MOTOR
  - VARIABLE SPEED CENTRIFIGAL PUMP
- STATIC MIXER
- TURBINE
- PULSATION DAMPENER
- * S = SILENCER, FA = FLAME ARRESTOR, T = TRAP

ACTUATORS

- PNEUMATIC ACTUATORS
- MOTOR OPERATED VALVE
- SOLENOID OPERATED VALVE
- CYLINDER OPERATED VALVE

IDENTIFICATION AND NUMBERING SYSTEM

B-1	BLOWER
C-1	CONVEYING EQUIPMENT
F-1	FAN
T-1	TANK/SUMP
ME-1	MECHANICAL EQUIPMENT (GENERAL)
MH-1	MANHOLE
P-1	PUMP
M-1	MIXER-AGITATOR

PIPE LINE DESIGNATIONS

2 - PF - PL-4 - FLOW (GPM)* - LINE NO.*

- LINE SIZE
- TYPE OF FLOW
- LINE MATERIAL SPEC.

* = OPTIONAL INFORMATION

CL	CHLORINE
CON	STEAM CONDENSATE
DCW	DOMESTIC COLD WATER
FL	FILTRATE
FB	FILTER BACKWASH
FG	FUEL GAS
FO	FUEL OIL
IA	INSTRUMENT AIR
LPA	LOW PRESSURE AIR
ND	NON-SANITARY DRAINS
PA	PLANT AIR
PR	POLYMER
PF	PROCESS FORWARD FLOW
PW	POTABLE WATER
SD	SANITARY DRAINS
SE	SEPTAGE
SL	SLUDGE
SM	SCUM
ST	STEAM
SN	SUPERNATANT
TD	TANK DRAIN
UD	UNDERDRAIN
UW	UTILITY WATER
WW	WASH WATER
CT	CONCENTRATE TRANSFER
RS	RECIRCULATION STREAM

FLOW ELEMENTS

- ORIFICE
- VENTURI FLOW ELEMENT
- FE — FLOW ELEMENT (* SIZE IN INCHES)
- FLUME (* SIZE IN INCHES)
- WEIR
- FI — ROTAMETER

INSTRUMENTS & ELECTRICAL DESIGNATIONS

- XX — NOTE 2; XX — NOTE 1 — INSTRUMENT-LOCALLY MOUNTED
- XX — INSTRUMENT-BOARD MOUNTED (LOCAL PANEL) LOCATION NOTE 6
- INSTRUMENT-BOARD MOUNTED (MAIN PANEL)
- INSTRUMENT-BACK OF MAIN PANEL
- INSTRUMENT-DUAL ELEMENT IN SINGLE CLOSURE
- EQUIPMENT MFR. SUPPLIED DEVICE
- BW — COMPLEX INTERLOCK (BACKWASH)
- OR / AND — SIMPLE INTERLOCK
- P — PURGE: * A-AIR, W-WATER
- TO / FROM — * T = TELEMETERING, * C = COMPUTER
- PI — PRESSURE (VACUUM) GAUGE
- PI — PRESSURE GAUGE W/SEAL
- ELECTRIC MOTOR
- OPERATING LIGHT * COLOR OR GD=GRAPHIC DISPLAY
- SHARED FUNCTION (DISTRIBUTED CONTROL)
- COMPUTER FUNCTION
- SIGNAL CONDITIONING (NOTE 7)
- EXISTING INSTRUMENT

INSTRUMENT TERMINOLOGY

UPPER CASE LETTER	FIRST LETTER PROCESS VARIABLE	MODIFIER (Δ)OR SECOND LETTER TYPE READING OR FUNCTION	THIRD/ FOURTH LETTER FUNCTION
A	ANALYZER (NOTE 1)	ALARM	ALARM
B	BURNER FLAME	-	-
C	CONDUCTIVITY	CONTROL/ CONTROLLER	CONTROLLER
D	DENSITY	DIFFERENTIAL(Δ)	DISC
E	ELECTRICAL (EMF)	ELEMENT	ELEMENT
F	FLOW RATE	RATIO (FRACTION) (Δ)	-
G	-	GLASS	GLASS
H	HAND	HAND	HIGH
I	CURRENT (ELECTRICAL)	INDICATING/ INDICATOR	INDICATOR
J	POWER	SCAN (Δ)	-
K	TIME	-	-
L	LEVEL	LIGHT (PILOT)	LOW
M	MOISTURE (HUMIDITY)	-	-
N	-	-	-
O	OPERATION	ORIFICE	-
P	PRESSURE/VACUUM	PRESSURE	-
Q	QUANTITY	TOTALIZER (Δ)	-
R	RADIOACTIVITY	RECORDING/ RECORDER	RECORDER
S	SPEED/STOP	SWITCH(NOTE 5)	SWITCH
T	TEMPERATURE	TRANSMITTER	TRANSMITTER
U	MULTIFUNCTION	-	-
V	VISCOSITY	VALVE/DAMPER/ LOUVER	VALVE
W	WEIGHT	WELL	-
X	TORQUE	-	-
Y	-	RELAY (NOTE 2,5)	RELAY
Z	POSITION	DRIVE	-

NOTES:

1. THE FOLLOWING ABBREVIATIONS FOR ANALYSIS READING OR FUNCTION DESCRIPTIONS ARE TO BE PLACED OUTSIDE THE LOWER RIGHT QUADRANT OF THE BALLOON SYMBOL.

ABBREVIATION	DESCRIPTION
CO	COMBUSTIBLES
Cl	CHLORINE
DO	DISSOLVED OXYGEN
HOA	HAND/OFF/AUTOMATIC
ORP	OXIDATION REDUCTION POTENTIAL
pH	ACID/ALKALINE
RH	RELATIVE HUMIDITY
TOC	TOTAL ORGANIC CARBON
Tu	TURBIDITY
O	OXYGEN
DO	DISOLVED OXYGEN

2. TYPICAL DESIGNATIONS FOR INPUT/OUTPUT SIGNAL SEQUENCES ARE TO BE PLACED OUTSIDE THE UPPER RIGHT QUADRANT OF THE BALLOON SYMBOL.

ABBREVIATION	DESCRIPTION
A	ANALOG
D	DIGITAL
E	VOLTAGE
H	HYDRAULIC
I	CURRENT (ELECTRICAL)
O	ELECTROMAGNETIC OR SONIC
P	PNEUMATIC
R	RESISTANCE (ELECTRICAL)
Σ	SUMMATOR
1-0	ON-OFF
$\boxed{>}$	HIGH SELECTOR
$\boxed{<}$	LOW SELECTOR
$\boxed{f}$	FUNCTION GENERATOR

3. INSTRUMENT DESIGNATIONS SHOWN ON FLOW DIAGRAMS REPRESENT INSTRUMENT FUNCTIONS, NOT INSTRUMENT HARDWARE.
4. ALL INSTRUMENT IDENTIFICATIONS ARE BASED UPON "ISA" (INSTRUMENT SOCIETY OF AMERICA) STANDARDS. FOR FURTHER INFORMATION REFER TO "ISA" STANDARDS.
5. THE FIRST ELEMENT IN A LOOP IS A SWITCH. SUBSEQUENT DEVICES ARE RELAYS.
6. LOCATION OF LOCAL PANEL IF MORE THAN ONE IS USED

MCC	MOTOR CONTROL CENTER
PF	PRESSURE FILTER
GF	GRAVITY FILTER
VF	VACUUM FILTER

7. USE MATHEMATICAL SYMBOLS AND/OR NOTES TO DEFINE FUNCTION.

ABBREVIATIONS

A.S.	INSTRUMENT AIR SUPPLY	F.C.	FAIL CLOSED
N.C.	VALVE NORMALLY CLOSED	F.P.H.	FREEZE PROOF HYDRANT
N.O.	VALVE NORMALLY OPEN		
F.O.	FAIL OPEN		
S.T.	SAMPLE TAP		

KEYWORDS: 1. 2. 3. 4. 5.

BLDG./FACILITY — ROOM/AREA — GRID COORD./COL NO

MASTER

	BY	DATE
DESIGNED	M. KRESS	10/20/92
DRAWN	B. MANNING	10/20/92
CHECKED	M. CORBUN	10/20/92
APPROVED	R. [illegible]	10/20/92
SUBMITTED		
APPROVED RFP		
APPROVED		

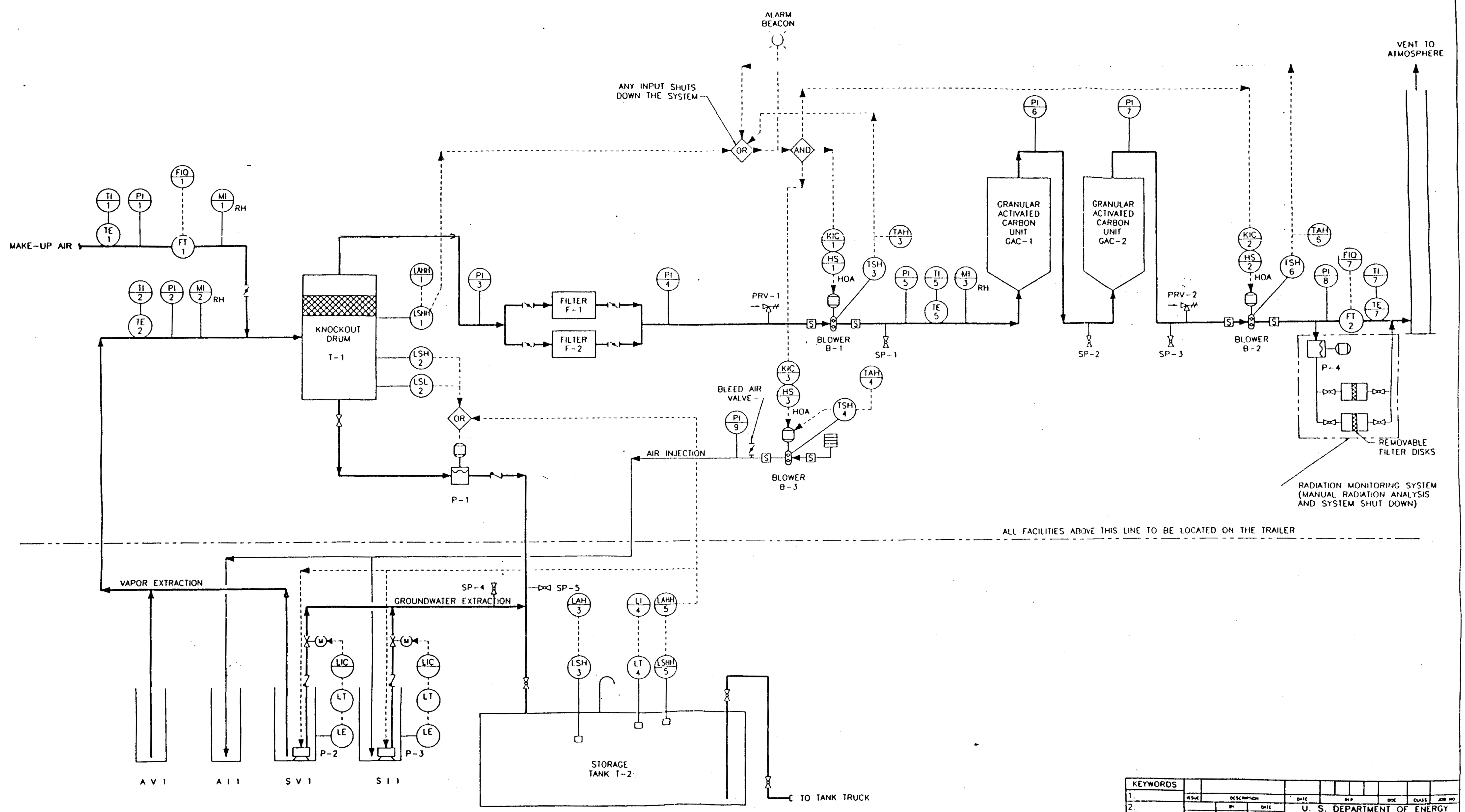
ISSUE | DESCRIPTION | DATE | RFP | DOE | CLASS | JOB NO

U. S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE — GOLDEN, COLORADO

ROCKY FLATS PLANT
GOLDEN, COLORADO 80402-0464

SUBSURFACE IM/IRA
EAST TRENCHES AREA
LEGEND - P & ID SYMBOLS

SIZE	DRAWING NUMBER	ISSUE	SHEET
D	10		10 of 11



KEYWORDS				
1.	ISSUE	DESCRIPTION		DATE
2.		BY	DATE	U. S. DEPARTMENT OF ENERGY
3.	DESIGNED	W KRESS	10/20/92	ROCKY FLATS AREA OFFICE GOLDEN, COLORADO
4.	DRAWN	B MANNING	10/20/92	ROCKY FLATS PLANT
5.	CHECKED	M CORDIN	10/20/92	GOLDEN, COLORADO 80402-0464
BLDG/FACILITY	APPROVED		10/20/92	SUBSURFACE IM/IRA
ROOM/AREA				EAST TRENCHES AREA
GRID COORD/COL NO				PLANT VAPOR EXTRACTION UNIT
MASTER	SUBMITTED / APPROVED / APPROVED DOE		SIZE D	DRAWING NUMBER 11 / SHEET 11 of 11

PLOTTED 12/29/92 3:56 pm
PLT SC 1=1 FILE NO 37014013